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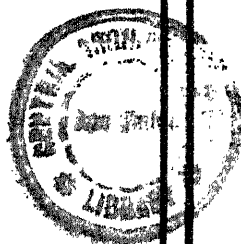
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Annual Report of the

Board of Scientific Advice for India

33772

for the year 1906-07



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PREFACE.

THE Board of Scientific Advice for India was constituted in 1902, and consisted originally of the heads of the Meteorological, Geological, Botanical, Forest, Survey, Agricultural and Veterinary Departments; but the Government of India intimated their intention to invite from time to time to serve upon it other scientific officers in the service of the Imperial and Provincial Governments, whose special attainments might render their assistance desirable. The Board was declared to be a central authority for the co-ordination of official scientific enquiry, its object being to ensure that the work of research is distributed to the best advantage, that each investigator confines his researches to the subject with which he is most capable of dealing, and that energy is not dissipated by the useless duplication of enquiries or misdirected by a lack of inter-departmental co-operation. It was also hoped that while the claims of abstract science would continue to be recognized in the work of the scientific departments, the Board's advice would aid the Government of India in prosecuting practical research into those questions of economic or applied science, on the solution of which the progressive prosperity of the country, especially as regards its agricultural and industrial development, so largely depends.

The Board advises generally upon the operations of the Departments, with due attention to the economic side of their work, and serves as a reference on all matters connected with the organization of scientific enquiry in India. It annually discusses the proposals of each departmental head in regard to the programme of investigation in his department; and in cases where inter-departmental co-operation is necessary, it advises as to the lines on which mutual assistance should be given and the department to which the enquiry should primarily appertain. It submits annually to the Government a general programme of research, embodying the proposals of departmental heads in so far as its subjects are to be exclusively dealt with in one department, and its own proposals in cases where two or more departments are to co-operate, and at the end of the year it presents a brief review of the results obtained during the year in all lines of scientific investigation controlled by its members. Its reports and programmes are communicated

through the Secretary of State to the Royal Society, who have appointed an Advisory Committee to consider them, and who from time to time furnish the Board and the Government of India with valuable suggestions and advice.

The present members of the Board of Scientific Advice are :

Name.	Appointment.
Mr. R. W. CARLYLE, C.I.E., I.C.S.	Secretary to the Government of India in the Department of Revenue and Agri- culture. <i>Ex-officio</i> President.
Colonel F. B. LONGE, R.E.	Surveyor-General of India.
Dr. GILBERT T. WALKER, M.A., Sc.D., F.R.S.	Director-General of Observatories.
Mr. T. H. HOLLAND, F.G.S., F.R.S., A.R.C.S.	Director, Geological Survey of India.
Captain A. T. GAGE, I.M.S., M.A., B.Sc., M.B., F.L.S.	Director, Botanical Survey of India.
Dr. N. ANNANDALE, B.A., D.Sc.	Superintendent, Natural History Section, Indian Museum.
Mr. S. EARDLEY-WILMOT, C.I.E.	Inspector General of Forests.
Mr. J. W. MOLLISON, M.R.A.C.	Inspector-General of Agriculture.
Colonel H. T. PEASE, C.I.E., I.C.V.D.	Inspector-General, Civil Veterinary Depart- ment.
Mr. I. H. BURKILL, M.A., F.L.S.	Reporter on Economic Products to the Government of India.
Colonel S. G. BURRARD, R.E., F.R.S.	Superintendent, Trigonometrical Surveys.
Dr. MORRIS W. TRAVERS, D.Sc., F.R.S.	Director, Indian Institute of Science.

*List of Sub-Committees.***Sub-Committee A.**—(*Meteorology, Terrestrial Magnetism and Cognate Subjects*).

1. The Surveyor-General of India (Chairman) ;
2. The Director-General of Observatories ;
3. The Director, Geological Survey of India.

Sub-Committee B.—(*Agricultural Products*).

1. The Director, Botanical Survey of India (Chairman) ;
2. The Superintendent, Industrial Section, Indian Museum ;
3. The Inspector-General of Agriculture.

Sub-Committee C.—(*Soils and Manures*).

1. The Inspector-General of Agriculture (Chairman) ;
2. The Director, Geological Survey of India ;
3. The Inspector-General of Forests.

Sub-Committee D.—(*Forest Products*).

1. The Inspector-General of Forests (Chairman) ;
2. The Superintendent, Industrial Section, Indian Museum ;
3. The Director, Botanical Survey of India.

Sub-Committee E.—(*Veterinary subjects*).

1. The Inspector-General, Civil Veterinary Department (Chairman) ;
2. The Inspector-General of Agriculture ;
3. The Superintendent, Natural History Section, Indian Museum.

Sub-Committee F.—(*Libraries*).

1. The Director, Geological Survey of India (Chairman) ;
2. The Director-General of Observatories ;
3. The Superintendent, Industrial Section, Indian Museum ;
4. Colonel S. G. Burrard, R.E., F.R.S. ;
5. Morris W. Travers, Esq., D.Sc., F.R.S.

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ANNUAL REPORT
OF THE
BOARD OF SCIENTIFIC ADVICE
FOR INDIA

FOR
1906-07.

SUMMARY OF PROCEEDINGS.

10th Meeting held at Simla on 6th May 1907.

THE Board had first under consideration the remarks of the Advisory Committee of the Royal Society of London on the staff and general scientific work both in the field and in the laboratory of the Imperial Civil Veterinary Department. As the remarks of the Advisory Committee had been referred by the Government of India to the Inspector-General of the Civil Veterinary Department for report the Board resolved to wait for the latter's reply.

The Board then discussed the remarks of the Royal Society's Advisory Committee on zoological subjects, in the course of which the establishment of zoological laboratories and small teaching museums in all the large University Colleges of Northern and Western India and an increase in the permanent staff of the Natural History Section of the Indian Museum were advocated. With regard to this the Board

were given to understand that proposals for an increase in the permanent staff of the Natural History Section of the Indian Museum had been submitted to Government by the Trustees of that Museum.

The comments of the Advisory Committee on the inadequate number of the staff of the Royal Botanic Garden, Calcutta, with regard to the demands of the Botanical Survey of India; on the delay in the publication of certain volumes of the Annals of the Royal Botanic Garden, Calcutta, and on the progress of the proposed Manual of Indian Cultivated Plants were discussed. The Board resolved to accept the report of the Director of the Botanical Survey and to endorse his explanation of the delay in the appearance of certain volumes of the Annals of the Royal Botanic Garden. As regards the Manual of Indian Cultivated Plants the Board resolved to refer the subject to Sub-Committee B to report what form such a Manual should take, the agency by which it should be prepared and what steps could be taken towards making a commencement.

The suggestions offered by the Advisory Committee with regard to a further investigation of Lathyrism in India, the collection of statistics of production by the Forest Department, and the cross breeding of wheat and other crops by the Agricultural Department were considered by the Board, who were informed that the subject of Lathyrism was under the consideration of the Government of India and that the other investigations were already being conducted on the lines suggested.

Correspondence regarding the revision of the Dictionary of the Economic Products of India and the cultivation of Flax in India was read and recorded.

With reference to a letter from the Government of India regarding the systematic examination of small mammals likely to act as carriers of plague infection the Board were informed that a pamphlet on the subject would shortly be issued under the supervision of the Superintendent of the Natural History Section of the Indian Museum.

The programmes of work for 1907-08 of the various scientific departments were discussed. The Board resolved to ask the Inspector General of the Civil Veterinary Department to draw up a revised programme of the work to be done at Muktesar with regard to the remarks of the Advisory Committee of the Royal Society. The programmes of the other departments with minor emendations were recommended for acceptance by Government.

The Board resolved to suggest to the Government of India that Dr. Morris W. Travers, D.Sc., F.R.S., Director of the Indian Institute of Science, should be invited to serve upon the Board.

11th Meeting held at Calcutta on the 20th December 1907.

After formal business was transacted the Board had under consideration a letter from the Government of India with enclosures embodying a report by the Director of the Botanical Survey of India with comments by the Director of the Royal Botanic Gardens, Kew, on the proposed reorganisation of the Botanical Survey of India. The Board resolved to refer the question to a special Sub-Committee consisting of the Director of the Botanical Survey of India, the Superintendent of the Industrial Section, Indian Museum, the Inspector-General of Agriculture and the Director of the Geological Survey of India for report to the Board at the next meeting.

A letter from the Government of India regarding the future organisation of the Economic Products Department and a memorandum by the Reporter on Economic Products on the same subject were read. The Board resolved to refer the subject to a special Sub-Committee consisting of the President of the Board of Scientific Advice, the Secretary to the Government of India in the Department of Commerce and Industry or an officer to represent him, the Inspector-General of Agriculture, the Inspector-General of Forests, the Superintendent of the Industrial Section, Indian Museum, the Director of the Botanical Survey of India and the Director of the Indian Institute of Science for report to the next meeting of the Board.

Endorsements from the Government of India forwarding correspondence on the subject of the proposed revision of the Dictionary of the Economic Products of India, on meteorological subjects and on veterinary subjects were read and recorded.

The draft Annual Report of the Board for 1906-07 was then considered. It was resolved that after certain alterations in the various sections of the report it be approved of and that each contributor should be supplied with 50 copies of his contribution.

The distribution list of the Annual Report was then read and the additions and alterations suggested by the Board noted.

A further report of Sub-Committee D (Forest Products) on the manufacture of wood-pulp for paper making and a note by the Director

of the Geological Survey of India on the investigation into the movement of glaciers were read and recorded.

Proposals by the Director of the Geological Survey of India for the investigation of the origin of salt in Rajputana were read. The Board approved the proposed investigation and expressed the opinion that the subject should be referred to the Geological Survey Department.

Proposals by Dr. M. W. Travers and Mr. T. H. Holland for the institution and reform of Scientific Libraries in India were read and the Board resolved to appoint an additional permanent Sub-Committee F to deal with such questions. This Sub-Committee to consist of the Director of the Geological Survey, Chairman; the Director-General of Observatories, the Superintendent of the Industrial Section, Indian Museum, Colonel S. G. Burrard, R.E., and Dr. Morris W. Travers.

ANNUAL REPORT FOR 1906-07

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INDUSTRIAL AND AGRICULTURAL CHEMISTRY

BY

J. W. LEATHER, PH.D., F.I.C., F.C.S.,
Imperial Agricultural Chemist,

AND

D. HOOPER, F.C.S., F.I.C.,
Curator, Indian Museum.

India-rubber.—Considerable interest is still being manifested in rubber secretions yielded not only by cultivated trees, but also by wild plants of all kinds that appear to yield a caoutchouc-like latex. Samples of finished rubber from the Para rubber (*Hevea brasiliensis*) plantation at Mergui have been examined with very satisfactory results. In connection with these plantations, Mr. E. P. Stebbing has investigated the life history of *Termes Gastroi*, the Hevea rubber termite, with a view to combat its ravages. In the nest of this termite, there is usually found a mass of rubber either as a result of a natural flow of the latex following upon the wounding of the trees by the insects or by the abnormal exudation due to a previously diseased condition of the tree. A sample of this rubber was submitted to analysis and it was found to be exceptionally pure, containing 96·7 per cent. of caoutchouc. It would appear that the termites had reduced the proportion of resins by consumption or by some chemical process of separation in the crude latex.

Further investigations have been made of the latices of wild Indian fig trees, but none of the samples, so far, approach in composition the superior quality of the secretion of *Ficus elastica*. The five samples of the following species contained large quantities of resinous constituents, and a caoutchouc content as indicated:—*Ficus tomentosa* 31·2; *F. retusa* 24·1; *F. bengalensis* 21·4; *F. Rumphii* 12·6; and *F. glomerata* 4·9 per cent.

The latex of *Streblus asper*, called "On hue" in Burma, is of a similar character. The latex afforded 25 per cent. of solid crude rubber which consisted of 22·9 per cent. of caoutchouc, 76·5 per cent. of resins and 0·6 per cent. of ash.

Pontianak, the gutta of *Dyera costulata* (W. A. Tilden, *Chem. News*, 1906, 94, 102). The latex yields 44 per cent. of solid matter, almost completely soluble in alcohol and in acetone. The caoutchouc is mixed with two or more other substances of which one, melting at 173° , is crystalline, and contains 81.2 per cent. of carbon and 11 per cent. of hydrogen, corresponding approximately to the formula $C_{14}H_{22}$. P. van Romburgh (*Proc. K. Akad. Wetensch.*, 8, 1906, 137) found lupeol to be a constituent of this gutta-percha.

Gum and Resins.—The oleo-resin of *Hardwickia pinnata*, a tree of Tinnevely, South Kanara and Travancore, has been examined by D. Hooper (*Pharm. Journ.*, LXXVIII, 4). Two authentic samples from South India were tested as to their composition, and their physical and chemical constituents determined. The properties of this exudation are sufficiently characteristic to distinguish it from copaiba balsam and gurjun oil (*Dipterocarpus turbinatus*).

The gum resin of the mango tree (*Mangifera indica*) has for the first time been analysed and definitely described (*Pharm. Journ.*, LXXVIII, 718). It is a resinous gum containing about 79 per cent. of resin and 15 per cent. of arabinoid gum. Museum samples differ much in their composition, a fact which throws doubt upon the authenticity of their origin.

H. H. Robinson has examined the gum of *Cochlospermum Gossypium* (*Proc. Chem. Soc.*, 22, 314). By hydrolysing the gum with water a dibasic acid of the formula $C_{23}H_{36}O_{21}$ was obtained, for which the name gondic acid is proposed. Two sugars were also separated, one xylose, and the other a hexose, possibly galactose. A colloid substance, α -cochlosperminic acid, was also present. The original gum yielded 14 per cent. of acetic acid.

Oils and Oil-seeds.—The chemical composition of the chief oil-seeds of India has been detailed by Dr. J. W. Leather (*Memoirs Dept. of Agriculture in India*, Chemical Series, 1907, I, 13—38). The analyses have been made by the usual methods except in the determination of the oil, in which, after the bulk had been extracted with ether the residue was dried in the air, crushed again, and once more extracted. The list of seeds which have been examined includes:—Earthnut (*Arachis hypogæa*), Mowha (*Bassia latifolia*), Sarson, Toria and Rai (*Brassica spp.*), Safflower (*Carthamus tinctorius*), Taramira (*Eruca sativa*), Cotton seed (*Gossypium*), Niger seed (*Guizotia abyssinica*),

Linseed (*Linum usitatissimum*), Poppy (*Papaver somniferum*), Castor (*Ricinus communis*), Til, jinjilly (*Sesamum indicum*).

Babu S. N. Dey (*Agricultural Ledger*, No. 5 of 1906) records the analyses of the seeds, oil-cake and oil of the silk-cotton tree (*Cochlospermum Gossypium*). The seed forms a nutritious food for cattle. The oil which occurs to the extent of 14 to 15 per cent. in the seeds occupies an intermediate position between a semi-drying and non-drying oil.

The seeds of the candlenut tree (*Myristica canarica*) of the Western Coast, after being powdered, are pressed into bamboos and made into candles. The seeds contain half their weight of fat, melting at 39°C. The fat saponifies with great facility, yielding 92 per cent. of crystalline fatty acids, melting at 41°. By crystallisation from alcohol, crystals of myristic acid were obtained showing that the fat consists largely of myristicin. The seeds and mace of *M. malabarica* yield considerable quantities of a similar fat which might be utilised for technical purposes. (Hooper in *Agricultural Ledger*, No. 3 of 1907.)

In a paper on "Fats of *Garcinia* species" (*Journ. and Proc. Asiatic Society, Bengal*, Vol. III, No. 5, 257-259), D. Hooper gives the results of examinations of fatty oils of *G. Morella* and *G. indica*, trees of Mysore and Bombay, respectively. While the constituent parts of these two fats are almost identical, the interesting fact is elucidated that in *G. indica* the olein is present in the proportion of one to two of stearin, forming oleo-distearin; while in the fat of *G. Morella* the olein is present in the proportion of two to one of stearin, forming steardo-olein.

In a preliminary note on the chemical examination of the milk and butter-fat of the Indian buffalo, E. R. Watson (*Journ. and Proc. Asiatic Society, Bengal*, Vol. II, No. 7, 1906, 293) has shown in what respects the constituents differ from those in cow's milk. From the crystalline form, taste, optical rotation, molecular weight and behaviour with Fehling's solution, the sugar of buffalo milk is identical with lactose. The butter-fat consists of the glycerides of the following acids in the proportions named:—butyric 4·83 to 5·52, caproic 0·37 to 0·42, oleic 30·4 to 41·7, palmitic and stearic acids 46·6 to 57·9 per cent. Compared with the butter-fat of the Egyptian buffalo and the European cow the percentage of volatile fatty acids in the Indian fat is very high. This is probably the best criterion for Indian buffalo fat. In the latter

product the volatile fatty acids are almost entirely butyric. The ratio between the butyric and caproic acid is $\frac{1}{4}$ for the Indian buffalo, $\frac{1}{4}$ for the Egyptian buffalo and $\frac{3}{8}$ for the European cow. These results, if confirmed by further analyses, should prove of the greatest use in recognising Indian buffalo fat in chemical analysis.

In a paper on Annamese bees wax by J. Bellier (*Ann. Chem. anal. appl.*, 1906, 11, 366-368), it is interesting to observe that this product differs from that of Europe, and closely approximates with the characters of the wax of *Apis dorsata* from British India. (See *Agricultural Ledger*, No. 7 of 1904.)

Regarding the aromatic grass oils, opinion has differed greatly as to whether the two rusa grasses "Motia" and "Sofia" are different varieties, or one and the same plant in different stages of maturity. A further contribution has been made to this topic during the year in the collection in the Nimar district of the Central Provinces of specimens of the two plants together with the essential oils belonging to them. The samples were forwarded by the Reporter on Economic Products to Messrs. Schimmel & Co., of Leipzig, for comparison with other grass oils. The examination resulted in the interesting fact that the oil distilled from "Motia" was a palmarosa oil, and the other one a ginger grass oil. Both distillates possessed the odours characteristic of the respective oils, and by these means could be readily distinguished from each other. The chemical analysis at once showed a great difference between the two oils. The ginger grass oil from the "Sofia" plant agreed completely with one thoroughly examined before, and it would probably have the same chemical composition. The plants were submitted to Dr. Stapf, who declared that they could not be distinguished morphologically, but both belonged to the narrow-leaved form of *Cymbopogon Martini* Stapf.

Further researches on East Indian sandal wood have been conducted. F. W. Semmler and K. Bode (*Ber.*, 1907, 40, 1124-1145) fully describe santalol prepared by saponification and fractionation of the oil as well as its alcoholic constituents.

Dyes and Tans—Indigo.—The accurate estimation of the amount of indigotin in commercial indigo has been the subject of four communications in the past year. Messrs. Bergthell and Briggs after considering various methods already in use, and after testing those which possess any claims to precision, conclude that indigotin is

most accurately estimated by heating the indigo with concentrated sulphuric acid so as to form the disulphonate; water is then added, together with some freshly precipitated barium sulphate. The indigotin is estimated in an aliquot part of the clear solution by potassium permanganate. For the estimation of the indigotin in plant leaf a modification of Rawson's method is considered accurate. To the aqueous extract of the leaf hydrochloric acid and ammonium persulphate are added, but with the precaution of avoiding any serious excess of the persulphate. The precipitated indigotin is filtered off and the indigotin estimated as described above. Messrs. Bergtheil and Briggs find that the impurities present in indigo influence the accuracy of the permanganate method to a serious extent; they find that the precipitation of these by addition of barium chloride (Rawson's method) or calcium carbonate (Grossmann's method) occasions a co-precipitation of the disulphonate. (*Vide Journal of the Society of Chemical Industry*, 25, 729.)

Mr. W. P. Bloxam, having also tested the various methods in use, finds it most accurate to prepare the tetra-sulphonate by heating with fuming sulphuric acid, formation of the potassium salt from this, which is washed free of impurities and then dissolved in hot water and titrated either with permanganate or titanium chloride. Mr. Bloxam shows the amount of indigotin found in specimens which he took from India in 1904, and from these figures he calculates the amount of indigotin which was originally in the leaf. Finally assuming that the indigo leaf originally contained exactly '6 per cent. of indigotin, he concludes that the efficiency of the process as used in Behar varies from 12'5 per cent. to 50 per cent. It is needless, however, to point to the uncertainty of the premises adopted. (*Vide Journal of the Society of Chemical Industry*, 25, 735.)

These views have been combated on both sides. On the one hand, Messrs. Orchardson, Wood and Bloxam produce evidence that Rawson's method as used by Bergtheil and Briggs yields too high results, and publish also information regarding some of the characteristics of indigo-gluten, indigo-brown and indigo-yellow. Some work was also done on the enzyme of the indigo plant leaf and on the use of Baeyer's condensation of indoxyl and isatin for the estimation of indigotin in the leaf. (*Journal of the Society of Chemical Industry*, 26, 4.) On the other hand, Bergtheil and Briggs, in a subsequent paper, criticise

Bloxam's tetra-sulphonate method and produce evidence that it yields too low results. (*Journal of the Society of Chemical Industry*, 26, 182.) Rawson has also published a paper in support of Bergtheil and Briggs' method and criticises Bloxam's adversely. (*Journal of the Society of Dyers and Colourists*, 1906, 22, 306.)

Important papers on some constituents of natural indigo have also been published by A. G. Perkin and W. P. Bloxam. Part I is concerned with an investigation of the constituents of natural indigo, known under the name of "indigo brown." Crude Bengal indigo was freed from "indigo gluten" by boiling with dilute hydrochloric acid, and the "indigo brown" extracted by boiling pyridine. After removing small quantities of indirubin by acetic acid, this substance, after drying at 100°C., had the composition corresponding to the formula $C_{16}H_{12}O_8N_2$, and its properties closely resemble those of indigo brown of Berzelius and the indihumin of Schunck. It is probably a complex indoxyl derivative. Small quantities of two other brown compounds were isolated, closely resembling the first mentioned compound. Bloxam's statement that indigo contains a non-nitrogenous red substance could not be confirmed; the only red substance was indirubin. Part II. Indigo yellow.—Rawson has drawn attention to the existence of a peculiar yellow compound in Java indigo from *Indigofera arrecta*, and Bergtheil detected a small quantity of the same compound in indigos made at Pusa from the same plant. From a sample of Java indigo the author isolated a yellow compound and identified it as kampferol, $C_{15}H_{10}O_6$. Kampferol is contained in the plant in the form of a glucoside, kampferitrin. A determination of the yield of kampferol from a sample of the air-dried leaves showed that they contained about 4 per cent. of the glucoside.

In a paper on Indican by A. G. Perkin and W. P. Bloxam (*Chem. Soc. Proc.* 1907, 23, 116-117) the isolation of this glucoside from *Indigofera sumatrana* and *I. arrecta* is shown to be effected by a simple method devised by the authors and its properties are described.

Datisca.—A. Korozynski and L. Marchlewski (*Anz. Akad. Wiss. Krakow.*, 1906, 95-101) have made a study of the colouring matter of the root of *Datisca cannabina* from fresh material obtained from the Punjab and forwarded through the Reporter on Economic Products. A glucoside was obtained as a yellowish-white material melting at 190°C. The product was hydrolysed yielding a sugar and a compound, $C_{15}H_{10}O_6$,

named datiscetin. Datiscetin contains four hydroxyl groups, yielding tetra-acetyl and tetra-benzoyl derivatives. It is isomeric with luteolin and fisetin, and is probably a flavone or flavonol derivative; on heating with alkalis it yields phenol and salicylic acid.

Tanning materials—During the year an Agricultural Ledger (No. 3 of 1906) has been published dealing with the chemical composition and trade forms of cutch, the extract of the wood of *Acacia Catechu*. The analyses are given of over sixty samples of extract from different parts of India and Burma, and the results are compared with those of gambier and other tanning materials. A method of detecting adulteration in catechu is to separate the extract obtained by means of alcohol of 90 per cent. A good quality of catechu should yield 70 per cent. of extract and upwards, and a fair quality 60 to 70 per cent., while 50 per cent. or less should be regarded as very inferior. The ash limit of 5 per cent. should exclude all worthless specimens, since the mineral constituents of a large number of samples of Burmese cutch averaged only 2·9 per cent.

Medicinal Products.—Dr. Chuni Lal Bose (*Calcutta Medical Journal*, September 1906) has examined the fruits of the bitter variety of *Luffa ægyptiaca* Mill. They contain two toxic glucosidal principles, one of which is soluble and the other insoluble in chloroform. The former is a severe emetic with only slightly irritant properties in the bowels, while the latter seems to possess no emetic properties, but causes irritation in the lower bowels giving rise to dysenteric symptoms. The latter, from its chemical behaviour and its physiological action, closely resembles colocynthin. No alkaloids were obtained from the fruits. Messrs. Naylor and Chappel have isolated from the fruits of *Cucumis trigonus* Roxb., a bitter glucosidal principle apparently identical with colocynthin.

As everything relating to jute is of interest to India, the investigation of the toxic glucosides in certain jute seeds by R. Kobert (*Sitzb. Ber. naturf. Ges.* Rostock, 1906. *Apoth. Zeit.*, 1907, 22, 179) should be referred to. The seeds of *Corchorus fascicularis* are mucilaginous, sweet, non-toxic, and edible; those of *C. olitorius* are purgative; those of *C. capsularis*, *C. bengalensis*, *C. acutangulus*, *C. argutus* and *C. trilocularis* contain fat; and the last three, besides a green fluorescent body, a toxic glucoside, the corchorin of Tsuno

and W. Friboe. Corchorin is very poisonous being allied to the digitalis glucosides.

Ipomæa Turpethum.—(E. Votocek and J. Kastner *Apoth. Zeit.*, 1907, 22, 259). The authors find that besides turpethin, the resinoid body insoluble in ether, the rhizome contains a previously undescribed glucosidal resin now named turpethin, soluble in pure ether.

Samples of Hops (*Humulus Lupulus*) grown in Kashmir have been examined in the Industrial Section of the Indian Museum and were found to yield 13.2 and 12.9 per cent. of oleo-resin by Coez's benzol method. The yield is thus not far below that of North French hops of commerce.

Food stuffs.—Tubers called Singapuri keshur are sold as a vegetable in the Calcutta market. They have been determined as the roots of *Eleocharis tuberosa*, and have been analysed in the Indian Museum. They are composed of water 4.34; fat 0.71; albuminoids 8.12; carbohydrates 77.47; fibre 3.70; and ash 5.66.

The seeds of *Phaseolus lunatus*, "Pois de Java," have been analysed by E. Kohn-Abrest (*Comptes rend.*, 1906, 142, 586-589). The seeds yield hydrogen cyanide on macerating with water and subsequent boiling with hydrochloric acid. In eight varieties the amounts varied from 0.528 to 1.638 grms. per kilo. Cold dilute hydrochloric acid only liberates very small quantities of hydrogen cyanide.

Tea.—A second paper on the fermentation of tea has appeared in which Dr. Mann recapitulates the results of experiments regarding the effects of several additional factors.

In the previous paper he produced evidence in favour of a temperature of 78–82° F. during fermentation and opposed to a higher one than 84° F. Dr. Mann now adds similar evidence showing that a temperature below 75° F. causes the process to be unduly protracted and occasions a loss of flavour. Regarding *flavour*, which is attributed to an essential oil, the experiments go to show that it is not increased during the withering process, but that during rolling it is rapidly formed and a further increment occurs in the earlier part of the fermentation. The maximum "flavour" is attained in about three hours. On the other hand, for the production of a maximum "thickness of liquor" a period of more than four hours is necessary. Two other points are dealt with, the one being the large amount of oxygen absorbed by the leaf during fermentation, 4.5 lbs. having abstracted the oxygen

from 1 c. ft. of air, and the consequent necessity for ventilation is emphasised; the other, the necessity for rapid drying of the fermented leaf.

Alcoholic Liquors.—An excellent report has been published by Major C. H. Bedford on the quality, manufacture and excise control of alcoholic liquors in India, the memorandum being an official summary of the work done in the Central Excise Laboratory, Kasauli. The manufacture of country spirit is fully described and numerous tables are given showing the strength and composition of potable spirits prepared at different localities and under varying conditions. In a paper read before the Society of Chemical Industry, entitled "The Determination of Higher Alcohols in Spirits" (*Journ. Soc. Chem. Ind.*, XXVI, 1907, 123-126), Messrs. Bedford and Jenks discuss the usual analytical methods employed for estimating amyl, normal butyl, isobutyl, normal propyl and isopropyl alcohols constituting the higher alcohols in ethyl or ordinary commercial alcohol. The Allen-Marquardt process is an accepted one and was adopted for the purposes of the inquiry. While amyl alcohol by itself can be determined by this method with a high degree of accuracy, the intermediate alcohols are also returned with notably low results. In the present paper the authors publish their methods for extracting the whole of the higher alcohols from spirituous liquors, and describe the ester-iodine method for rapidly determining them in the extract.

"Available" plant food in Soils.—Some attention has been given to this subject in the Chemical Section of the Agricultural Research Institute and the results of three years' work were recently published as a Memoir of the Department (Chemical Series, Vol. I, No. 4). The primary object was to check the value of Dyer's method on a variety of Indian soils by means of Pot-Cultures. Eight soils were so tested and the experiments supported the value of the method. At the same time it is to be recognised that there is much need to perfect our methods in this direction and it consequently continues to be a subject for investigation.

Soil Moisture.—This subject has been taken up at the Agricultural Research Institute, Pusa, in part because so little is at present known about the actual amount of water which is present in soils, and still less regarding the rate at which loss of water occurs during dry weather, or of the distance through which water moves during these

periods ; in part because information on these points in respect of water would provide an index regarding the movement of plant foods or injurious salts.

The data obtained during the first year are about to be published as a Memoir of the Agricultural Department. The following are briefly the deductions which have been made :—

- (a) Water is lost from a soil from a limited depth only ; this depth increases with the period of time involved ; it is assumed that it will vary with the nature of the soil, though, since the work was done on only one soil, experimental proof is required of this.
- (b) The rate of loss of water depends in part on atmospheric temperature and humidity ; in part on the quantity of water present in the soil, *i.e.*, it follows the " compound interest law." Consequently the loss is greatest immediately after rain and decreases with the time. This explains why the amount of loss by evaporation has been found at Cawnpore to be so little in excess of that recorded at Rothamsted. The former is apparently about 17" per annum, the latter about 14".
- (c) The greatest distance which water was found to move at Pusa during the approximately dry period of nearly nine months was somewhat more than three feet. The drying effect was experienced to a depth of seven feet.
- (d) It is commonly stated that the water-holding and water-retaining capacity of the soil depends on its " physical character." Whilst credence may very properly be given to this statement, it is devoid of any sense of precision and an attempt is being made to determine those particular physical characters which control retention of water. In the past year the connection between ability to retain water with the surface possessed by the soil particles has been studied, and a general relationship established ; but it is too early to form an opinion as to whether success will be achieved in this direction. It is intended to extend the observations on the retention of water and maintain records at three other places in the Indo-Gangetic alluvium, in order to include a greater

variety of conditions of soil and climate respectively than can be obtained at Pusa.

Arabian well waters.—An examination has been made of samples of well-waters from the Hadhramaut Coast. The water issues from subterranean lakes and possesses great fertilising properties especially conducive to the cultivation of a high grade tobacco. The saline constituents of the water consist chiefly of alkaline sulphates with only minute quantities of nitrates.

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ASTRONOMY

BY

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Solar Physics.—Research in solar physics is carried on under the direct control of the Government of India at Kodaikanal, the Director being Mr. Michie Smith. The staff received a large increase of strength when Mr. J. Evershed took over his duties as Assistant Director in January last. Since 1st April 1907, Mr. Michie Smith has been away on leave. The chief instruments are :—

- (a) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is that of making photographs of the sun using the light emitted by one chemical element only.

In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror, and so emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be adjusted in such a position as to allow light of any desired wave length to pass through. In the Kodaikanal spectroheliograph the collimating and camera lenses, each of 5-inch aperture and 6-foot focal length, together with the prisms and slits, are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the image of the sun while the secondary slit will move at an equal rate across the sensitised plate; and

as in each position an image will be formed at the second slit by light of the desired wave length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic light. At present the H and K lines of calcium are largely used on account of the convenience afforded by the width of their absorption shading and the fact that the centre of the dark line is frequently 'reversed,' *i.e.*, is bright instead of dark, indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows bright clouds—called 'floculi'—of calcium vapour scattered about over the sun and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the 'prominences' projecting from the sun's margin.

This instrument has been completely overhauled during the year and various devices for improving the definition have been adopted, including a diminution of the amount of exposure to sunlight of the ground near the instrument and the removal of a very stiff spring inside the 12-inch lens. The result of the changes has been very satisfactory.

- (b) Two 6-inch refractors, with one of which an Evershed spectroscope has been used since November 1904.

These are used for visual examination of the sun and for spectroscopic study of spots and prominences.

- (c) A spectrograph consisting of an 11-inch polar siderostat with a 6-inch Grubb lens of 40-foot focus. This is used with a 4-inch concave grating of 10-foot focus mounted on Rowland's plan, or a parabolic grating collimated to cure astigmatism, or a plane grating with collimator and camera lenses of 8-foot focus. A powerful spectrograph has also been erected in the spectroheliograph room, using a 3-inch plane grating. It is employed in photographing the ultra-violet region in spot spectra and in studies on the line of sight movement of the chromospheric gases. Both spectrographs have been fitted with

special occulting shutters for regulating exposures in spot spectrum work.

- (d) A photoheliograph by Dallmeyer. With this a photograph of the sun in ordinary light is made daily when possible. Originals are sent to Greenwich for the use of the Solar Physics Committee for those days for which photographs are not available from Greenwich or Dehra Dun.

2. In addition to the use of the spectroheliograph and photoheliograph the routine work includes visual examination of sunspots and faculæ, observations of widened and displaced lines in sunspot spectra and spectroscopic observations of prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review," while for more technical purposes bulletins of the observatory are issued. Of these eleven have appeared, the last including the spectroscopic observations of sunspots down to the end of February 1907.

The scope of the work has been enlarged during the year by the use of the parabolic grating in connexion with the 40-foot spectrograph and the bringing of this instrument into constant use in the study of spot spectra. Photographs are now made in which different exposures are given for the spot and for the adjacent photosphere in order that equally dense images of both spectra may be obtained: these are then copied and enlarged with a special apparatus so as to bring out the characteristic features of the spot spectrum with the greatest clearness. Estimates of the amounts of intensification or of enfeeblement of the lines in spots can thus be satisfactorily determined. Detailed measurements of the characteristic spot bands in the neighbourhood of "b" have been made in co-operation with Professor Fowler with a view to the careful comparison of their positions with the bands of magnesium hydride. Photographs have also been obtained showing a considerable number of affected lines in sunspots in the violet and ultra-violet regions of the spectrum.

One of the more interesting of the year's results has been the identification of dark markings in the spectroheliograms with prominences seen in projection on the disc.

The observatory is now co-operating with the "International Union for Solar Research."

There is also at Poona, under the Government of Bombay, the Takhtasingji Observatory, where research in solar physics is carried on by Mr. Naegamvala. The chief portions of the equipment are:—

- (a) A Foucault 12-inch siderostat with an 8-inch image lens and a spectroscope with a $1\frac{1}{4}$ -inch Rowland grating. With these daily observations are made of the twelve most widened lines in sunspot spectra in the region D-F. The results have been forwarded monthly to Sir Norman Lockyer, and very close agreement of these observations with those at South Kensington has been attained. The appearance of the line D_3 and reversals of C and F are also noted whenever observed. Proposals for an improvement in the equipment are under consideration.
- (b) An equatorial refractor with a Cooke 6-inch triple photo-visual lens. This is provided with two 45° objective prisms, and a prominence spectroscope with a Thorpe transmission grating has been constructed locally for attachment to it.
- (c) An equatorial reflector with a 20-inch mirror by Common. A focal plane spectrograph had previously been received from Sir H. Grubb, but repairs to the dome had prevented the telescope from being mounted. When this was done alterations in the mounting of the mirror were found necessary and these have only recently been completed.

The observatory has also undertaken to assist in the scheme for the observation of sunspot spectra drawn up by the "International Union for Solar Research."

Solar Radiation.—The equipment at Simla for measuring solar radiation consists of two Angstrom pyrheliometers which arrived from England in October 1906 and a third, presented to the department by Dr. Sven Hedin, which arrived at the end of May 1907.

At Calcutta there is a Callendar radiation recorder.

The object for which the observations are made is that of determining the nature and amount of the changes in the radiation given off by the sun, rather than the amount of it which reaches the earth: and experience has shown that the difficulties are by no means easy to overcome. A trace of cloud, or of smoke from the neighbouring

bazaar, which may be so faint as to be scarcely perceptible to the eye, is sufficient to diminish materially the reading of the instrument; and at certain times of year the observations are rendered practically useless either by the dust which rises from the strongly heated ground or by currents of air from which it is difficult to protect the instrument without modifying the radiation to which it is subjected. In June for example the radiation on apparently clear days, as measured, is distinctly less than in November and December, although in the latter case the zenith distance of the sun is about 54° as compared with 8° in June. Of the two instruments sent from England, one was slightly deranged in transit and the arrangements for instituting comparative observations at Roorkee are in consequence not yet carried out.

The approximate values of the radiation as measured at Simla during the various months have been, in gramme calories per minute per square centimetre,—

November 1906	1.49
January 1907	1.49
March	1.55
April	1.51
May	1.40
June	1.32
November	1.44

METEOROLOGY

BY

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Study of Seasonal Variations of Climate.—The statistical methods which were employed last year have been applied to additional data and have confirmed the general character of the results previously obtained. It has for instance been shown that the high pressure in the Argentine Republic which is associated with numerous sunspots extends to Honolulu and to Washington; and further that the general tendency for pressure relationships with abundant Indian monsoon rainfall to be similar to those with numerous sunspots holds good for Honolulu, but probably not for Washington.

In view of the fact that the department was founded as late as 1875 it is only for 32 years that reliable data of most of the Indian meteorological elements are available. This is somewhat short for trustworthy inferences as to causal relationships and an attempt has been made to push the limit further back. In pressure this can be done: for the mean of the annual pressure departures at Calcutta, Bombay and Madras is practically identical with that of India, and the data of the three stations extend back to 1855. For rainfall a backward extension is more difficult: actual tabulation shows very material differences between the result given by 50 well distributed stations and that of 2,500 stations, while the result of 450 stations also differs appreciably from the latter. It is therefore impossible to place confidence in conclusions drawn from stations fewer than 50 and decidedly irregular in their distribution. For most purposes therefore it may be said that the rainfall of India as a whole begins to be trustworthy at about 1865 and is not accurately known before 1875. This view is supported by what is known of the earlier famines and also by the fact that the relationships of rainfall with sunspots and some other factors as deduced from the earlier years are different from those given by the later years.

Statistical methods show that of the data which are available at the beginning of June those which are most closely associated with abundant rainfall in the ensuing monsoon are low pressure at Mauritius in the previous May, high pressure in the Argentine Republic and Chili in the period March to May, deficient subequatorial rainfall in May as given by Zanzibar and Seychelles, deficient snowfall in May, and high pressure in India during the previous year.

When estimating the most likely quantity of monsoon rainfall the resultant effect of these cannot be obtained by adding their separate effects, for they are not independent of one another. Using the phrase 'correlation coefficient' of two mutually dependent quantities with its ordinary meaning of the proportionate extent to which the variations of either are governed by those of the other, * the mutual

* Thus if the factors are independent the coefficient is zero, if they always move by exactly proportionate amounts either increasing or decreasing together it is +1, and if by exactly proportionate amounts in opposite directions it is -1. If one half of the variations of one quantity are governed by those of the other and the remaining half by accidental circumstances the coefficient is $\frac{1}{2}$.

influence of the previously mentioned quantities and of the monsoon rainfall of the previous year are indicated in the following table in which the correlation coefficient between two quantities is to be found at the intersection of the row and the column corresponding to them :—

—		Maur. pressure.	S. Amer. pressure.	Subeq. rain.	Snow.	Press. prev. yr.	Rain prev. yr.
Monsoon rain .		—'45	+ '55	—'25	—'40	+ '35	0
Maur. pressure .		+ 1'00	—'15	+ '25	+ '05	—'45	+ '25
S. Amer. press. .		—'15	+ 1'00	0	—'60	+ '10	+ '35
Subeq. rain .		+ '25	0	+ 1'00	+ '45	+ '15	+ '05
Snow . . .		+ '05	—'60	+ '45	+ 1'00	+ '15	—'30
Press. prev. yr.	+ '35	—'45	+ '10	+ '15	+ '15	+ 1'00	—'55
Rain prev. yr. .	0	+ '25	+ '35	+ '05	—'30	—'55	+ 1'00

It must be remembered that owing to the fewness of the years which are available the probable errors in this table vary from '09 to '12.

From this there follows by ordinary statistical methods—

$$\left\{ \text{Monsoon rain} \right\} = -\cdot 2 \left\{ \text{Maur. pressure} \right\} + \cdot 4 \left\{ \text{S. Amer. pressure} \right\} \\ -\cdot 2 \left\{ \text{subeq. rain} \right\} - \cdot 1 \left\{ \text{snow} \right\} + \cdot 3 \left\{ \text{press. prev. yr.} \right\}$$

where the equation connects the proportional departures of the quantities within brackets, the proportional departure being the ratio of the actual departure to its mean value over the series of years. If this formula be applied to the data of the successive years in the past the

calculated departures of monsoon rainfall are those contained in the following table together with the actual departures:—

YEAR.	RAINFALL DEPARTURE.		YEAR.	RAINFALL DEPARTURE.	
	Calculated.	Actual.		Calculated.	Actual.
1875 . . .	+1'8	+4'4	1891 . . .	-3'4	-2'9
1876 . . .	-3'5	-2'5	1892 . . .	+3'6	+4'9
1877 . . .	-4'6	-7'1	1893 . . .	-0'5	+3'6
1878 . . .	+2'3	+2'8	1894 . . .	+2'9	+4'7
1879 . . .	+2'4	+2'3	1895 . . .	+0'8	-2'7
1880 . . .	+0'2	-1'7	1896 . . .	+1'6	-1'1
1881 . . .	-1'5	+1'8	1897 . . .	-2'1	+0'4
1882 . . .	+1'2	+2'2	1898 . . .	+0'3	+0'6
1883 . . .	-1'5	-1'3	1899 . . .	-3'9	-7'0
1884 . . .	-1'4	+2'2	1900 . . .	-0'2	+1'1
1885 . . .	+0'7	+0'4	1901 . . .	+0'7	-4'6
1886 . . .	+2'6	+0'9	1902 . . .	-1'3	-1'6
1887 . . .	+1'4	+1'4	1903 . . .	+0'4	-0'3
1888 . . .	-1'8	-0'4	1904 . . .	-1'0	-2'2
1889 . . .	+3'6	+2'3	1905 . . .	-1'5	-2'9
1890 . . .	+2'3	+1'8	1906 . . .	-1'2	-0'1

It will be seen that the rainfall departures as forecasted by the formula agree on the whole moderately well with the actual departures; and the correlation coefficient of the calculated and actual proves to be .7. If we consider the 24 years in which the forecasted departure exceeds 1" the question of excess or defect in the subsequent monsoon is rightly indicated in 20 cases and wrongly in 4 cases. It has unfortunately happened that this year's monsoon with a calculated excess has had an actual deficit of 3'1". Curiously enough the pressure in South America and the Indian Ocean have remained extremely

favourable on the whole, and it seems necessary to attribute the early withdrawal of the monsoon to some important factor that is at present unknown.

Among the details which have been ascertained during the year may be mentioned a remarkable relationship between pressure at Mauritius and the position of the trough of low pressure in Upper India during June, July and August : if the former pressure rises the trough tends to move a few days afterwards towards the foot of the Himalayas, and *vice versa*. The connection was close enough this year to enable the rises and falls in the weekly pressure at Mauritius to be inferred from the daily weather maps in at least three cases out of four.

Meteorological charts of the Indian Ocean. Owing to the kindly cooperation of the meteorological offices at London, Washington, Hamburg and Mauritius, originals or copies of ship's logs have been secured in addition to those obtained by departmental officers at Calcutta and Bombay. The attempts to produce daily, weekly or monthly charts are, however, disappointing : there are no readings at all over a considerable portion of the map, and even where the pressure readings are most numerous their average errors are such as to make the resulting means in general untrustworthy for the investigation of seasonal variations. From time to time, however, the pressure departures may be large enough to be indicated with some reliability, and as the winds are correctly recorded it is proposed to plot the data of groups of seven days each on one chart and to examine for decidedly abnormal features, such as the northerly winds which have prevailed at times this year between Mauritius and the equator during the rains.

Investigation of the Upper Air.—Kiteflying at Belgaum. The work which Mr. Field started last year at Belgaum with the object of investigating the meteorological conditions of the upper air during the monsoon period by means of kites has been continued during the past year. The kites which had been previously used were repaired and strengthened, and several new kites of the pattern used by Dines in England were made in Simla. On the 11th of July the hut at Belgaum containing the oil engine and winding gear was opened and preparations made for flying the kites. For several days no rain fell and winds were only light, there being a break in the monsoon current which had not as yet set in with its normal intensity. On the 14th, 15th, and 16th the winds increased in strength and the conditions became favourable for kiteflying with

the result that heights varying between one and one and-a-half miles were reached each day : the weather could not however be regarded as thoroughly typical of the season.

The monsoon became reestablished on the 17th when rain fell and the wind increased considerably. During this day the highest kite ascent yet made in India was effected and good instrumental records were secured of the meteorological conditions up to a height of about twelve thousand feet above sea level. This flight although entirely successful was attended by considerable risk, for the wind became high and two of the four kites used having become unstable considerable difficulty was experienced in landing them unbroken. After this the monsoon set in with considerable vigour and the wind and weather conditions became such that kiteflying was impossible. It was not the average strength of the wind which caused the difficulties but the fact that the velocity varied irregularly from something like 20 miles an hour up to 60 miles or more, and throughout no single hour could moderate conditions be expected. The weather was dominated by rainstorms which moved rapidly across country in the direction of the wind, and each covered an area with a diameter of about two miles. A rain centre would appear on the horizon and pass over the kite station in about half an hour ; the wind in the front of this would rise to great violence and then die down to nearly a calm midway between this storm and the next, which would appear after a short interval. Naturally these storms proved fatal to the kites and as a consequence every attempt to obtain an ascent ended in failure. The kites were broken and mended until hardly a serviceable kite remained, and the whole of the time which could be given to this work passed without another successful ascent being made.

The results have been tabulated and are now being published. It may be remembered that in 1906 a dry layer was as a rule found at a height which varied from day to day between 2,500 and 8,300 feet above Belgaum, but conditions were only favourable for kiteflying at times when the weather was not thoroughly typical of the monsoon, and hence it cannot be inferred that the dry layer persisted when the rains were fully established. In 1907 this dry layer was once found at a height of about 5,000 feet, but not at any other time although heights considerably greater than those of 1906 were attained.

This experience has clearly shown that kiteflying during the monsoon

is much more difficult than had been anticipated and that methods peculiar to the circumstances must be developed. There is, however, no reason to expect that the difficulties will prove insuperable, nor that they should require a great expense of time or material in overcoming them.

Kiteflying over the Bay of Bengal and the Arabian Sea.—Shortly after returning from Belgaum Mr. Field proceeded to England on privilege leave : he had previously obtained permission to attempt to fly kites from the deck of the British India steamer on which he sailed from Calcutta on the 23rd of August. Four new kites having been rapidly made and a few of the old ones repaired before starting, Mr. Field was able to make four ascents in the Bay of Bengal and three in the Arabian Sea. The work was again full of difficulties, and one or two losses were sustained ; but it is expected that the records secured up to a height of 9,000 feet will give valuable information.

Balloons.—As mentioned in last year's report measurements are being made in Simla of the velocity and direction of the air currents in the upper atmosphere. In most civilized countries the implements used for exploring the atmosphere are 'ballons-sondes' or sounding balloons which are filled with hydrogen and carry to extremely great heights very light instruments that automatically record the meteorological conditions of the air as they pass through it. Such methods would have very great value in this country : for a knowledge of the temperature, humidity and direction of motion of the air would be of great value both to Indian meteorology and to meteorology as a general science. The conditions however make the use of recording instruments very difficult. A balloon sent up to reach very great heights would probably be carried hundreds of miles before reaching the ground again : and even if the place where it fell were sufficiently populous for it to be found it would not be likely to be returned owing to the ignorance and superstitions of the peasants. Under these conditions it appears wiser for the present to limit the work to the determination of the winds at different heights, and to ascertain the course and velocity from observations made with two theodolites at the ends of a measured base line, no attempt being made to recover the balloon. Readings of altitude and azimuth without the use of verniers are made alternately at intervals of twenty seconds, the theodolite being kept directed at the balloon by a second observer.

In November 1906 two ascents were made on the 9th and 22nd, the balloon being followed to heights of 29,000 and 34,000 feet respectively above sea level. On both these occasions the wind at the highest point reached was blowing almost exactly from the west, the divergence being not more than three degrees in either case. The velocity of the wind also was considerable, 54 miles an hour being reached at the highest point on the first date, and 80 miles an hour at the greater height on the second occasion. The next ascent effected on the 27th of February, showed almost exactly the same conditions as those prevailing on the 9th November. The height reached was 28,000 feet, the velocity was 49 miles an hour and the wind was exactly due west.

In March two more ascents were made and are interesting as showing how rapid changes may take place in an interval of a very few days. On the 4th a height of 32,000 feet was obtained and the wind was blowing there with a velocity of as much as 103 miles an hour. In direction also it was somewhat different from the usual west wind in that it was blowing from a point 19° to the south of west. Nine days later, on the 13th, the conditions had altered considerably : the balloon moved less quickly in a horizontal direction and was accordingly followed to a greater height than had previously been found possible. It was not lost until it had reached a height of 58,000 feet above sea level and its horizontal velocity, after rising to about 60 miles an hour, dwindled at the highest point to only 27 miles an hour. The direction of the wind also had undergone a change ; it was then blowing from a point 30° south of west, this being one of the greatest divergencies from a true west wind yet found at a great height above Simla.

The previous results show, as might be expected from what is known of the general air circulation, that the wind in the upper atmosphere over Simla has always a large westerly component ; but it is not so constant in either direction or velocity from day to day as might have been imagined.

Electrical Condition of the Atmosphere.—Although what is known of the electrical conditions of the atmosphere throws little light on the causes of the great meteorological changes, it seems very probable that some relationship must exist between the two classes of phenomena. The connexion between sunspots, magnetic storms and auroras shows that the sun's activity does affect the electrical and magnetic conditions of the earth's atmosphere, and with greater knowledge of the latter

some information as to the former may be expected. Broadly speaking the electrical condition of the atmosphere is defined by the state of ionisation of the air and by the electric potential gradient above the earth's surface. Last year apparatus was installed at both Calcutta and Simla for making determinations of these two factors, and in April 1907 a Benndorf self-registering electrometer was brought into use at Simla for automatically recording the variations in potential gradient. This instrument is now providing daily curves which will be discussed when a year's records have been obtained.

Apparatus for automatically and constantly recording the ionisation and conductivity of the air has been designed and is being made in the workshop of the Simla office. It is expected that this instrument will be in use before the end of the year; and the result derived from a comparison between its records and those of potential gradient should give valuable information.

Arrangements have also been made for measuring the quantity of electricity carried down by rain and other forms of precipitation. The insulated receptacle for the precipitation together with the mechanism for automatically recording its quantity and the quantity of electricity brought down with it have been placed in a hut which has been specially designed to protect the apparatus from the earth's field and from the effects of splashing. This instrument was completed at the end of the rains in Simla and there has been as yet no chance of obtaining any results.

Publications.—In addition to the Daily Weather Reports published at Simla, Calcutta, Bombay and Madras, the Monthly Weather Reviews, the Annual Summary, and various administrative pamphlets, the following memoirs have been published in the series of memoirs of the department:—

A discussion of the anemographic observations recorded at Rangoon from June 1878 to October 1901.

A discussion of the anemographic observations recorded at Chittagong from June 1879 to December 1896.

Both are by Sir J. Eliot, K.C.I.E., F.R.S. who is writing a series of memoirs on the winds of India.

The following memoirs are now in the press:—

A discussion of the anemographic observations recorded at Saugor Island from March 1880 to February 1904.

A discussion of the anemographic observations recorded at Ali-pore from March 1877 to February 1904.

A discussion of the anemographic observations recorded at Allahabad from September 1890 to August 1904.

A discussion of the anemographic observations recorded at Lucknow from June 1878 to October 1892. All four are by Sir J. Eliot, K.C.I.E., F.R.S.

Kite flights made at Belgaum during the premonsoon and monsoon periods in 1906. By J. H. Field, M.A., Imperial Meteorologist.

A meteorological atlas of the Indian Ocean north of latitude 12° S. has also been prepared, chiefly by Mr. Dallas, and is being published by Messrs. Bartholomew. The data of pressure and winds are based on logs collected in India from 1893 to 1904 and the atlas contains monthly normal charts of the pressure, winds, sea currents, and tracks of storms, together with charts of typical storms, and statements of the chief features contained in the charts.

TERRESTRIAL MAGNETISM

BY

GILBERT T. WALKER, M.A., ScD., F.R.S.,

Director-General of Observatories.

Magnetic Observatories.—*Bombay (Colaba and Alibag).* The tabulation and discussion of the series of magnetic observations at Colaba which extend over sixty years is approaching completion. Attempts also have been made to obtain satisfactory explanations of the discrepancies which appear in the past records owing to differences of site and of instrumental exposure. The observations are now made at Alibag, the electric tramways at Bombay rendering Colaba useless for the purpose: the autographic instruments at Alibag are of the Watson pattern and the old Kew pattern instruments will shortly be transferred thither.

Dehra Dun, Kodaikanal, Barrackpore and Toungoo.—Of these observatories, which have been established as base stations in connection with the magnetic survey, the first two were started in 1902, the third in 1903 and the last in 1904: they are all equipped with Watson

autographic instruments for declination, horizontal intensity and vertical force. The instruments for vertical force at Kodaikanal, Barrackpore and Toungoo were erected during the year under review, and after adjustment of the temperature compensation the following determinations of the temperature coefficients were made:—

Dehra Dun -5.27 per 1° Fahr., Barrackpore $+3.97$, Toungoo -2.17 and Kodaikanal $+3.47$. All these instruments have given good results except that at Kodaikanal where the magnet which had proved unsatisfactory at Dehra Dun has been temporarily mounted pending the installation of a new magnet in December next: it appears likely that the agate knife-edge of the present instrument is defective.

The temperature coefficient of the Toungoo horizontal force magnetograph which had previously given trouble owing to the system not having reached a steady state was satisfactorily determined, the value found being 7.47 per 1° Fahr.

Earth inductors of the Schulze pattern have been installed in each observatory in place of dip circles, than which they are much more satisfactory. The mutual agreement of the new instruments is excellent, the greatest difference between two of them being $0.2'$. One of the inductors has accordingly replaced dip circle No. 44 as the standard of the survey, and the difference of the indications is—

Inductor No. 30—Dip circle No. 44 = $+0.8$.

The mean values of the magnetic elements at the observatories for 1906 are as follows:—

	Declination.	Horizontal Force.	Dip.
Bombay	$1^{\circ} 55' \text{ E.}$	36874	$23^{\circ} 7' 9$
Dehra Dun	$2^{\circ} 39' 2' \text{ E.}$	33365	$43^{\circ} 29' 8$
Barrackpore	$1^{\circ} 14' 1' \text{ E.}$	37259	$30^{\circ} 26' 4$
Kodaikanal	$0^{\circ} 36' 3' \text{ W.}$	37435	$3^{\circ} 21' 1$
Toungoo	$0^{\circ} 43' 6' \text{ E.}$	38715	$21^{\circ} 59' 2$

Magnetic Survey.—The preliminary survey of India for which sanction has been given is planned to involve —

- (a) Observations for declination, intensity and dip at about 1,100 stations, whose distance apart will be comparable with 35

or 40 miles, the "density" being one station to 1,300 square miles.

- (b) Observations in successive years of the magnetic elements at 23 "repeat stations" in order to make possible the elimination of secular variation.
- (c) Data from absolute and self-registering instruments at Bombay and the four special base stations already mentioned.

A beginning was made with field work in November 1901 and the operations up to the end of the year 1905-06 have been described in previous reports : by that time 958 stations had been occupied and 22 repeat stations established. During the past year field operations have been carried on by four detachments, two in Burma, one in Assam, Manipur and Lushai, and the fourth in Chota Nagpur, the Agency tracts of Vizagapatam and the tributary states of Orissa. In addition, observations were made at eight stations grouped round Buxar to investigate the abnormal value of declination found in 1903-04. The total number of new stations visited during the year was 152 and of stations occupied to date is 1,110 with 22 repeat stations. The field season commenced on the 19th October 1906 and the party proceeded to recess quarters on 1st May 1907.

The officer in charge of the Magnetic Party was Captain R. H. Thomas, R.E., and a second Imperial officer Lieutenant H. J. Couchman, R.E., was posted to the party in September 1906: with his assistance all the repeat stations, 22 in number, were visited. The officer in charge inspected the observatories at Dehra Dun, Barrackpore, Kodaikanal and Toungoo, and carried out comparative observations at each to determine the differences from the survey standard.

In addition the magnetic survey is indebted to Captain C. M. Browne, D.S.O., R.E., for observations of the magnetic declination at 25 stations on the Seistan trade route with equipment supplied by this party. Included in these observations is the largest value of east declination observed during the present survey, *viz.*, 5°E. at Malikshah in Lat. $29^{\circ} 1' 42''$ Long. $62^{\circ} 58' 57''$.

During the recess season the computations of the field work and the reduction and tabulation of the base station results for 1906 have been completed. The field instruments were all compared with the survey

standards at the beginning and end of the field season. Further investigations have been made with regard to the correction of the field observations for diurnal variation. From the results from the four base stations, Colaba, Dehra Dun, Barrackpore and Kodaikanal, simple formulæ connecting change in diurnal variation with change in latitude had already been established, by which using the results of two base stations the diurnal variation at any third station may be determined: in the present investigation the results of Toungoo observatory were included to determine whether the formulæ would still hold good within the wider limits of longitude. The results were quite satisfactory, and the formulæ have now been established for the limits of the Magnetic Survey of India.

It was again noticed that the results when using the Kodaikanal H. F. values were never so satisfactory as when this observatory was excluded from the discussion: in the reduction therefore this observatory will not be used, if the curves from two other base stations are available. The discordance is probably connected with the fact that this observatory is situated on rock which is distinctly magnetic.

Investigations into the variation of disturbances from point to point are in progress at the present time on lines suggested by Sir A. Rucker. The investigations, which require a knowledge of the variations of the vertical component of the earth's field, could not be commenced until results from the V. F. magnetographs were available, and the installation of these instruments was completed only in March last.

During the next field season, the last of the preliminary survey, three detachments will be employed in Burma and its administered tracts while a fourth will observe in India in such tracts as remain. It is estimated that 110 new stations will be established, which with previous work will give a total of 1,220. The extension of the survey into the Himalayas, which is most desirable, must be deferred until the detailed survey is begun.

It is hoped that the reduction of the field work may be so far advanced as to indicate before the field season 1908-09 the disturbed districts in which detailed observations should be taken: but this reduction cannot be properly effected until satisfactory formulæ, empirical or theoretical, have been found for the variation from point to point of disturbances, and sufficient data have been accumulated for the investigation of the proper values to assign to the secular change

in the districts intervening between the base stations: should then, as is probable, this reduction not be sufficiently advanced, the detailed survey may be begun by the examination of the northern edge of the Deccan trap which has already been asked for by the Geological Survey.

GEODESY

BY

J. ECCLES, M.A.,

Officiating Superintendent, Trigonometrical Surveys.

Trigonometrical Operations.

Principal Triangulation.—During the year under report the Principal Triangulation was extended in Baluchistan westwards from Longitude $64\frac{1}{2}^{\circ}\text{E.}$ up to Longitude $62\frac{1}{2}^{\circ}\text{E.}$ keeping along the parallel of 29° North.

The country in which the work lay is about as desolate and barren as any land could be and is practically uninhabited except for a few nomad shepherds and the inmates of the levy posts maintained along the Seistan Trade Route. It is, however, full of interest to the geologist and the surveyor.

Up to Longitude 63°E. the triangulation was carried on by quadrilaterals and a tetragon, but west of this the country presented considerable difficulty to the extension of the work, on account of the enormous sandy and stony plains which stretch as far as the eye can reach to the north and south of Koh-i-Sultan (an extinct volcano which lies about Latitude $29^{\circ}10'\text{N.}$, Longitude $62^{\circ}50'\text{E.}$).

Here a hexagon was employed with its central station on the highest point of Sultan (Miri) and the other stations on low hills except at Kondi, where the station was in the open plain.

Abnormal conditions of terrestrial refraction were met with and distinct evidence of earth tremors noted.

Observations to the plain station, Kondi, from the other stations were accomplished without any great difficulty; but when it came to observing from it, the most peculiar effects of refraction and its consequent mirage were noticed.

The ray Kondi-Tuzgi was about 20 miles in length, but a heliotrope, although cut down to 3" in diameter, in the middle of the day appeared

an enormous luminous disk subtending 4 minutes of arc with a "reflection" of equal size in the "water of the mirage": from this a luminous streak appeared to stretch to within a mile or so of the observer. The above figures give the heliotrope an apparent diameter of 120 feet, the real one being 3 inches.

Two heliotropes were often seen side by side and on one occasion three were visible.

To obviate the effects of this abnormal state of things, observations were made under as greatly differing conditions as possible and at different times of the day and night.

While the observations were proceeding in the plains great difficulty was being experienced in building a station on the summit Koh-i-Sultan: all the local stone split when wetted owing no doubt to the presence of unslaked lime and it was necessary to bring stone from a distance. Twice after completion the station was seriously cracked by earth tremors: such tremors occurred on several occasions during observation, causing a visible quivering of the instrument; they did not last long but occurred at any time of the day or night and had nothing to do with the atmospheric conditions.

At all the last stations the active volcano, Koh-i-Taftan, which is in Persian territory, was observed. When near it, large volumes of smoke were visible through the telescope constantly rising and spreading over its snow-capped peaks, one of which exceeds 13,000 feet in height.

There is a local tradition that Koh-i-Sultan was active within comparatively recent times and this is distinctly borne out by the appearance of the mountain. These remarks are of greater interest from the fact that in most books on volcanoes the highly volcanic region between Koh-i-Taftan and Koh-i-Sultan with its many distinct craters is either not mentioned at all or is dismissed with the barest of notes.

Observations for magnetic declination were taken at several stations east of Nushki: strong local attraction was found to exist at one or two places, but on the whole the declinations were in conformity with those already determined in Eastern Baluchistan and Sind. The length of the series was 150 miles and the triangular error deduced from 15 triangles was 0.41".

In Dehra Dun observations were taken at three stations of the Great Arc Series, Banog, the east and the west ends of the Dehra Dun Base and at one new station, Top Tiba, to see if any movement had

been caused by the earthquake of 1905. No movement was detected among these stations, but before it can be definitely stated that no movement has taken place, it will be necessary to continue the revision into the plains.

During the present field season the triangulation will be continued to the Persian border and a meridional Series will be commenced to connect the Kalat Series with the Mekran series. Another Series will be commenced starting near Kalat running in a north-easterly direction which will finally be joined on to the Great Indus Series. The Salween Series will be continued southwards to Latitude 22° , where it will bend eastwards towards Siam.

2. Himalayan Heights.—Observations of Himalayan heights in order to try and obtain some definite information on the difficult question of refraction were carried out during the year at four stations—Mussoorie, Nojli, Nag Tiba and Dehra.

At Mussoorie the heights of snow peaks, and of the two stations on the plains at Nojli, were lower in the spring of 1907 than in the autumn of 1906, the difference in the height of Bandarpunch being 11 feet, of Srikanta 8 feet, of Jaonli 5 feet, of Kedarnath 12 feet, of Nojli Tower Station about 12 feet and of Nojli ground level station about 9 feet. Similar differences were found in the preceding year.

It follows that in the past two years refraction has been greater in the autumn than in the spring.

The difference in the heights of snow peaks between the autumn of 1905 and the autumn of 1906, and between the spring of 1906 and the spring of 1907, were, respectively, as follows:—

Name of snow peak.	Autumn, 1905-06.	Spring, 1906-07,
	Feet.	Feet.
Bandarpunch	+ 7	0
Srikanta	+ 5	- 13
Jaonli	+ 8	- 10
Kedarnath	+ 16	No observations in spring, 1906.

During 1906-07, it sometimes happened that the angles of depression to the two stations at Nojli were less at 10 A.M. than at 8 A.M. by amounts varying from 2 seconds to 10 seconds; thus the heights of these two stations appeared from 2 feet to 10 feet higher at 10 A.M. than at 8 A.M. This is contrary to the common idea that refraction is greatest about 8 A.M.

At Nojli, the changes in the angle of elevation of Mussoorie at the time of minimum refraction have been very small during the years 1905-06 and 1906-07.

Owing to insufficient observations no statement can be made as to the seasonal changes in the heights of the snow peaks as seen from this station.

At Nag Tiba, the heights of snow peaks in the spring of 1907 were greater than in the spring of 1906, Bandarpunch being 8 feet, Srikanta 14 feet, and Jaonli 18 feet, higher.

There has been no change in the apparent difference of height between Mussoorie and Dehra or between Mussoorie and Nag Tiba during the years 1905-06 and 1906-07.

3. Base Line Apparatus.—As stated in last report Captain Turner, R.E., was deputed to study the whole question of the measurement of base-lines by means of Invar Wires. He visited the International Bureau of Weights and Measures at Sévres where he was treated with the greatest courtesy. His report has been published in pamphlet form. While he was at Sévres and afterwards he made strong representations in favour of a new metric standard instead of the present 10-foot Bar A. A radical change like this required careful consideration, but when Colonel Burrard wrote and said that Dr. Gill threw doubt on the accuracy of the comparison of Bar A, it was felt that a new standard would probably be necessary, the only question being whether the unit should be the foot or the metre. The foot is not a proper standard of length, since it is merely part of the length of a certain piece of metal under certain conditions, at a certain epoch, and is certainly liable to alter as time goes on. On the other hand, the metre derives its length from a certain physical quantity, namely, the wave-length of a certain line in the spectrum of cadmium, which can be reproduced. A metre is in fact equal to "1,553,164 times the wave-length of the red line of the spectrum of cadmium when the latter is observed in dry air at the temperature of 150°C. of the normal hydrogen-scale at a pressure of 760 m. m. of mercury at 0° C."

A further communication was shortly afterwards received from Colonel Burrard in which he said that he had interviewed Professor Darwin and Professor Baklund, the celebrated Russian Geodesist, and that both of these scientists were strongly in favour of the change to the metre being made in the Indian standard. Professor Baklund stated that the identical question had to be faced at Pulkowa and that they accepted the metre without hesitation.

Professor Darwin recommended that the 10-feet Bar A should be carefully compared in India against the secondary standard 10-feet Bars I_B and I_s and that it should then be sent to Sévres to have its length determined by Dr. Guillaume in metres, after which it should be sent to the National Physical Laboratory for evaluation in English feet, a second comparison being made with bars I_B and I_s after Bar A's return to India.

In accordance with this, it has been arranged to have Bar A compared very carefully with Bars I_B and I_s . The former will then be carefully packed and forwarded to Sévres through the India Office while the secondary bars will be carefully stored away to await the return of Bar A.

When such geodesists as Dr. Gill, Professor Darwin and Professor Baklund express such decided opinions in favour of the metre, there does not seem to be any other course open to the Indian Government than to adopt it for base-line operations. The unit employed in topographical work will still be the foot.

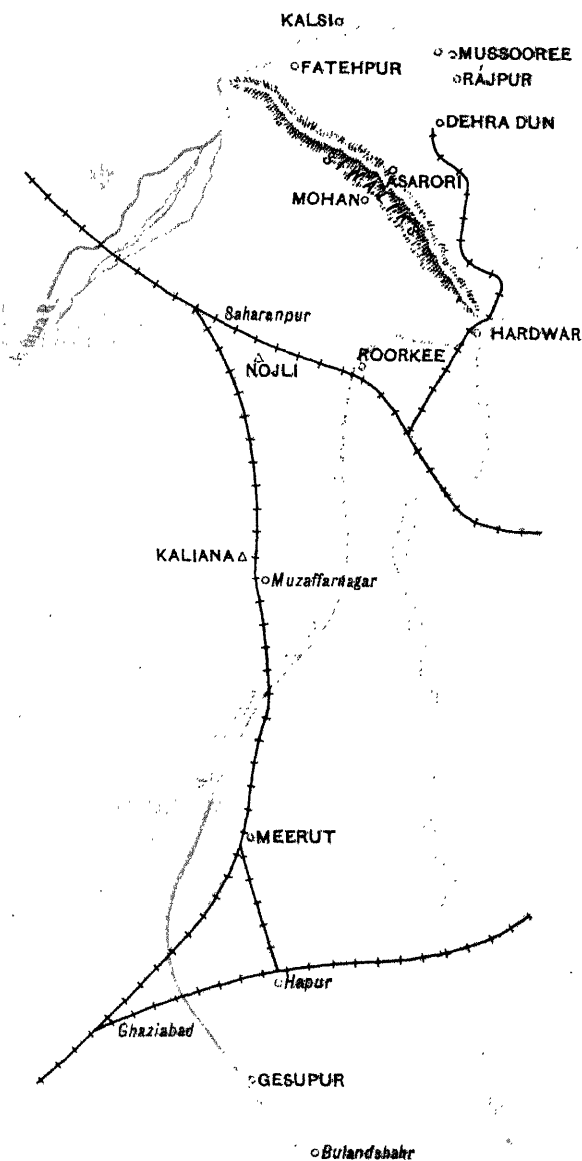
The wires necessary for field measurements will cost the same whatever the unit and the only extra expense in the field apparatus will be the cost of a 3 or 4 metre Invar bar for use in the field. Another 3 or 4 metre bar composed of whatever alloy of nickel and steel is now considered by specialists to be the most permanent will be required as the fundamental standard.

As soon as the apparatus arrives in India every endeavour must be made to measure whatever base-lines are necessary at once, as the triangulation, good as it is, has got too far away from the present base-lines to satisfy the views at present held in geodetic science.

Gravimetric Survey.

1. **Pendulum Operations.**—The programme of the year 1906-07 was framed so as to throw further light on the variation of gravity in the

SKETCH MAP SHOWING PENDULUM STATIONS OF 1906-07.



neighbourhood of the Himalayas and the Siwaliks. The stations selected were—

- | | | | | |
|-----------------------------------------------------------------------|---|---|---|--------------------------------|
| 1. At foot of Himalayas | . | . | { | Rajpur. |
| | | | { | Kalsi. |
| 2. In the Dun | . | . | . | { Dehra (already observed at). |
| | | | . | { Fatehpur. |
| 3. In or near the Siwaliks | . | . | . | { Asarori. |
| | | | . | { Mohan. |
| | | | . | { Hardwar. |
| 4. Outside the Siwaliks, but not far from them. | | | { | Roorkee. |
| | | | { | Nojli. |
| 5. Stations on or near the Great Arc extending southwards from Nojli. | | | { | Kaliana. |
| | | | { | Meerut. |
| | | | { | Gesupur. |

The results of the season's work were satisfactory. The temperature of the pendulums seems to be more correctly given by the thermometer fitted into the dummy pendulum, than it was by those which were attached to the stand; moreover, at all the stations visited, fairly good observing rooms were obtained.

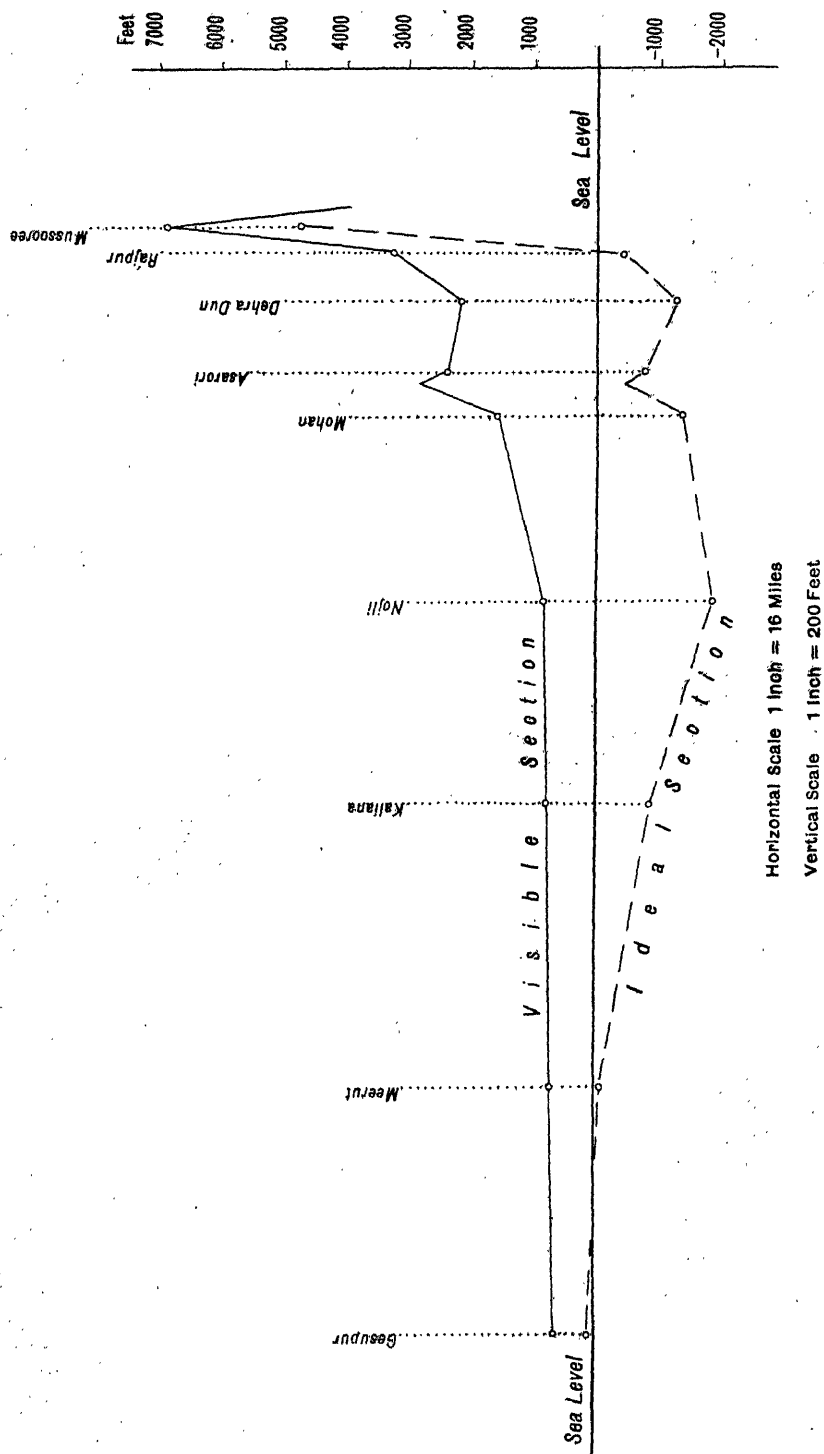
The differences between the observed values of g and the calculated values are shown in the following table which is of the same form as that given in last year's report (page 63):—

The attached sketch map shows the position of the stations.

		Excess or deficiency of observed force of gravity.	Visible excess of rock above sea-level height of station = H.	Invisible excess or deficiency of rock as revealed by the pendulum = D.	Resultant excess or deficiency of rock, i.e., height of station above sea-level if crust were reduced to normal density H. + D.
Station	Region.	c. m.	Feet.	Feet.	Feet.
Rajpur	} Foot of Himayas. {	—0'130	3,321	—3,700	—380
Kalsi		—0'105	1,684	—2,980	—1,296
Dehra .	} In the Dun . {	—0'123	2,240	—3,500	—1,260
Fatehpur		—0'100	1,415	—2,840	—1,425
Asarori .	} In the Siwaliks {	—0'112	2,467	—3,180	—713
Mohan .		—0'105	1,660	—2,980	—1,320
Hardwar		—0'114	949	—3,240	—2,290
Roorkee .	} Outside the Siwaliks. {	—0'107	868	—3,040	—2,172
Nojli .		—0'096	879	—2,730	—1,851
Kaliana	26 miles south of Nojli.	—0'058	810	—1,650	—840
Meerut .	62 miles south of Nojli.	—0'027	734	—770	—36
Gesupur	92 miles south of Nojli.	—0'020	691	—570	+121

The defects in the force of gravity are somewhat greater at Dehra Dun and Rajpur than at the similarly situated stations of Fatehpur and Kasli in the western Dun, but on the other hand the height of the two latter stations above sea-level is considerably less than that of the two former, and if we imagine the crust reduced to normal density, the depth below sea-level in the western Dun will be greater than at Dehra, though not so great as at Hardwar, Roorkee, and Nojli.

VISIBLE AND IDEAL SECTIONS FROM GESUPUR TO MUSSOOREE



The accompanying diagram is a section through Gesupur, Meerut, Kaliaana, Nojli, Mohan, Asarori, Dehra Dun, Rajpur, and Mussoor showing the actual profile of the ground and the profile when the crust is reduced to normal density.

On the meridian of Darjeeling and also on the line across the Punjab, stations were found at which the force of gravity was in excess of the normal value. At the most southerly of this year's station, Gesupur, the force was still in defect and it is probable that greater values will be found when the line is extended.

One of the most important objects to be borne in mind in designing future programmes is the locating of the exact position of the line, roughly parallel to the Himalayas, where the excess of gravity is a maximum. The existence of such a line is shewn by the latitude observations, but it cannot be satisfactorily located except by the pendulum.

Since the last report was written the results of the observations which Dr. Heckor made in conjunction with Major Lenox-Conyngham at Jalpaiguri in 1905 have been received.

He finds by direct comparison with Potsdam the value of the acceleration due to gravity at Jalpaiguri to be 979'624 c.m.

Major Lenox-Conyngham's result which is also based on the Potsdam value of g , through Kew and Dehra Dun is 979'622 c. m. The difference between the two is within the error of observation.

The accordance is highly satisfactory and gives confidence in the accuracy of the work so far accomplished.

During the coming year observations will be taken in the south of India at stations situated in different types of regions, such as the Mysore Plateau, the East and West Coasts, the Nilgiris, Pulneys, and Shevaroys, and in the Central plain. This part of India is geologically very different from the parts that have hitherto been visited and it will be of great interest to ascertain whether the characteristics which have been found both in the Himalayas and in the Suleiman Mountains are present in the Southern hills also.

Deflection of the Plumb-line.—During the season 1906-07, observations to determine the deflection of the plumb-line were taken at eleven stations in the Kathiawar Peninsula and round the Gulf of Cambay, distributed as follows:—

Three stations on the Kathiawar Meridional Series.

One station on the Kathiawar Minor Longitudinal.

Two stations „ Gujarat Longitudinal.

Five „ „ Singi Meridional Series.

In addition observations were taken at Dehra Dun for the purpose of ascertaining whether the earthquake of 1905 had created any disturbance in the distribution of local masses of such a nature as to cause to change in the value of the deflection of the plumb-line.

Troughton and Simms' Zenith Telescope No. 1 was used for taking the Talcott observations. At each station from 20 to 40 pairs of stars were observed.

The following table gives the results of the season's work :—

Name of station.	Latitude.	Longitude.	Height above M. S. L.	Deflection of the Plumb-line.
			Feet.	"
Dangarwadi. H. S. . . .	20°43'	70°59'	96	8'52
Kunkavav. T. S. . . .	21°39'	70°59'	591	1'65
Dungarpur. H. S. . . .	22°48'	71°2'	404	4'69
Chamardi. H. S. . . .	21°49'	71°58'	42	2'77
Ingrodi. T. S. . . .	22°57'	71°51'	118	5'08
Paldi. H. S. . . .	22 54'	72°34'	208	5'47
Ghorarao. H. S. . . .	22°52'	73°24'	323	3'12
Pavagad. H. S. . . .	22°28'	73°33'	2,721	4'38
Sidhpur. H. S. . . .	22° 4'	73°31'	169	3'44
Alamvadi. H. S. . . .	21°35'	73°33'	848	3'68
Tarbhan. H. S. . . .	21° 1'	73°6'	140	5'77

These results shew the prolongation still further to the south-west of the belt of the negative values of O-C, which runs south-west and north-east with the tract of maximum values approximate along the line Deesa-Agra. There are indications, besides, that to the south-west of Deesa the value of the northerly deflections is somewhat smaller than it is to the north-east. It also appears that over the southern portion of

the Kathiawar peninsula relatively large northern deflections may be expected; that over a central belt small northerly values will occur, which increase to the north.

The fact that the most southerly station, Dangarvadi, exhibits a greater northerly deflection than that of the northern station, Dungarpur, shows that the plumb-lines in the south and north of the peninsula are relatively inclined towards each other and this considered in conjunction with the result determined at the intermediate station, Kunkavav, which is smaller than either northern or southern value, indicates that there is a source of attraction within the peninsula itself.

If there are three stations approximately on the same meridian and one source of attraction lying either north or south of all three stations, the value of the deflection at the middle station will lie somewhere between those at the north and south stations. This is true for every source of attraction situated in a latitude either less than that of the southern station or greater than that of the northern. It is consequently true for any combination of such attractions. That is, in every case of a group of sources of attraction none of which lie in latitudes intermediate between those of the southern and northern stations, the value of the deflection at the middle station will be somewhat between those of the other two. To produce a deflection at the middle station not of this nature but greater or less than the other two, there must be a source of attraction lying between the latitudes of the north and south stations. The results in the table above give an instance of this. The deflection at Kunkavav is $-1.65''$ less than either of the values at Dangarvadi and Dungarpur, $-8.52''$ and $-4.69''$ respectively, showing that a source of attraction is to be looked for within the peninsula itself. The result found at Chamardi points to the same conclusion.

Considering only these three values, $-8.52''$ at Dangarvadi, $-1.65''$ at Kunkavav, and $-4.69''$ at Dungarpur and assuming that these deflections are due to a mass of relatively great density concentrated at a point somewhere in the line Dangarvadi-Dungarpur, it can be shown that if this point is situated anywhere between the surface and 5 miles below, its distance north of Dangarvadi would be about 50 miles. Much weight, however, cannot be given to any such result based on the above stated assumption, for in nearly all cases the ratio between the volume occupied by the mass and its distance from the station of observation is such as to render unsound the assumption that the mass

is concentrated at a point and consequently the law of inverse squares will not be applicable.

The general character of the Kathiawar deflections is what one is led to expect by a glance at the geology of the peninsula. The central portion is covered with basalt. Dangarvadi and Dungarpur are respectively close to the southern and northern edges, while Kunkavav is roughly over the centre of the basalt overflow. This being so, it was to be expected that the plumb-lines at the two former stations would be inclined inwards and from what has been said above that the value at Kunkavav would lie outside the range of the values at the other two stations.

At Thikri Latitude $22^{\circ}2'$ Longitude $765^{\circ}37'$ a deflection of $+0.84''$ had been found, the stations to the north and south of Thikri giving negative values. At Ghorarao, Pavagad, and Sidhpur were also found northerly deflections.

Thus at Thikri in the Nerbudda valley there is a small area of abnormal positive deflections.

The observations at Dehra Dun show that no change has taken place.

Tidal Operations.

During the past year tidal registrations by self-registering tide-gauges, were taken at the ports of Aden, Karachi, Bombay (Apollo Bandar), Bombay (Prince's Dock), Madras, Kidderpore, Rangoon, and Port Blair.

It was hoped that the tidal observatory at Moulmein would be ready early in the year, but various delays have occurred and the work on the observatory has not yet been commenced.

Nothing further has been done with regard to the proposed tidal observatory in the neighbourhood of Suakin.

The scheme proposed for the establishment of tidal observations at Kuwait and Bahrein in the Persian Gulf is now under the consideration of the Secretary of State for India, who is awaiting the results of experiments which are being made by the Admiralty with regard to a new pattern tide-gauge which is said to be better and cheaper than the pattern now in use.

A tidal wave caused by volcanic disturbance in the Bay of Bengal on 4th January 1907 was felt at Port Blair, Madras, Bombay, and

Karachi, but not at Aden or at any of the riverain stations. At Port Blair the tidal wave was more conspicuous than at any of the other Indian tidal stations where tide-gauges are at work. The first disturbance appeared to have commenced at 1-45 P.M. on 4th January 1907, the oscillations of the pencil due to the tidal wave were slight up to 2-40 P.M., after which they increased in frequency and in height up to 6-30 P.M., the time of slack water at low tide, when the wave was greatest, the height being 5 inches. After this the curve showed a diminishing of the wave until it ceased at 10-20 P.M. on 6th instant. The oscillations were most marked at each slack water at low and high tides.

Oscillations due to the tidal wave are traceable on the tidal diagram at Madras between midnight of 4th January and midnight of 5th. They are insignificant.

The effect of the tidal wave at Bombay is noticeable between 7 P.M. on 4th and 9 P.M. on 5th January, the oscillations of the pencil occurring only at or about the time of slack water at low and high tides. The greatest movement of the pencil out of the normal was 2 inches at 2-50 A.M. on 5th.

At Karachi the disturbance commenced at 5 P.M. on 4th about the time of slack water at low tide; and lasted till 10 A.M. on 6th January 1907. It was distinctly noticeable between 11 P.M. on 4th and 5 P.M. on 5th; at 1-15 A.M. at slack water at high tide on the 5th, the pencil showed an abnormal movement of the wave of 3 inches.

It was reported by the Director, Royal Alfred Observatory, Mauritius, that a tidal wave occurred at Mauritius, Rodrigues, and Reunion on the afternoon of the 4th January 1907.

The Director-General of Observatories in India reported that the Simla Seismograph recorded a large distant earthquake on the 4th January at 10-55 A.M. The distance of its centre from Simla was computed to be about 2,400 miles.

The tidal observatory at Karachi was wrecked on 6th June last by a cyclone which swept the cabin and tidal and meteorological instruments bodily into the sea. This occurred about 10-30 A.M.

The high water morning tide rose to 5 feet 3 inches higher than the predicted height for that tide, the actual being 12 feet 8 inches and the prediction 7 feet 5 inches.

The force of the wind was greatest between the hours of 9 A.M. and noon, the velocity being 85 miles per hour. The rainfall reported was

1'3 inches. The occurrence being reported, instructions were immediately sent to the Port Engineer to have tide-pole readings taken and to start the re-erection of the cabin. The work is almost complete and another set of instruments will be started at once.

The tide-gauge has been at work since 1881 and for the past 26 years gave a continuous and excellent record.

Owing to the contemplated enlargement of the Madras Harbour, the Port Engineer has stated that in all probability it will be necessary to remove the Tidal Observatory from its present position to some point on the new arm of the harbour which will project northwards.

Levelling Operations.

Levelling operations were carried out in the Punjab, United Provinces, Bombay Presidency, and Madras Presidency.

The total levelling executed amounted to 805 miles, of which 289 miles was new levelling and 516 miles revision work. The Bench-marks connected were 18 Standard, 70 embedded, 677 inscribed and 46 others such as railway, irrigation, etc.; 16 Trigonometrical Stations were also connected.

On the line Bombay to Kosgi, 8 embedded and 141 inscribed Bench-marks have been lost or destroyed, out of a total of 461. This is owing to the extension of railway stations and platforms, the renewal of bridges and culverts, duplication of railway line, etc. At Ahmednagar, when connecting the Standard Bench-mark there, 14 old Bench-marks could not be found; the bridge copings all along the railway were either being renewed or re-cobbled and many Bench-marks were found to have been destroyed by this means.

The revision of the level line, Bombay to Madras, was during the past season, carried as far as Kosgi, a station on the Madras Railway, distant 472 miles from Bombay.

The table below shows the discrepancies between the levelling of 1877-81 and 1906-07.

The mean sea level at Bombay derived from tidal observations taken in 1876-77 is 10'141 feet above the present zero of the gauge. The observed heights of 1877-81 are reduced to this datum.

The mean sea-level at Bombay deduced from tidal observation taken between 1878 and 1904 is 10'236 above the zero of the gauge. The observed heights of 1906-07 have been reduced by the levellers to

this datum. In order to make the observed values obtained in 1877-81 comparable with those of 1906-07.

A common datum line is required, which in the following table is the mean sea level of 1876-77. The difference .095 has therefore, with its proper sign, been applied to the heights of 1906-07 :—

Approximate distance in miles from Bombay.	Name of Bench-mark.	OBSERVED HEIGHTS ABOVE MEAN SEA LEVEL 1876-77, IN FEET.		Difference with sign for new value against old.	Heights published in Pamphlet, in feet.	REMARKS.
		Seasons 1877-81.	Season 1906-07.			
0	G. T. S. At Town ○ Hall, B. M. Bombay.	19'859	19'843	—'016	19'80	This is over the Bor Ghat.
2	G. T. S. At Prince's □ Dock. B. M.	10'855	10'815	—'040	10'70	
33	G. T. S. At Kalyan □ Railway B. M. Station.	25'270	25'242	--'028	24'91	
71	G. T. S. At Kam- □ poli Rail- B. M. way Sta- tion.	232'240	232'312	+ '072	231'73	
77	G. T. S. At Khan- □ dala B. M. Railway Station.	1790'885	1790'754	—'131	1790'36	
152	G. T. S. At Ked- □ gaun B. M. Railway Station.	1776'889	1776'773	—'116	1776'18	
165	G. T. S. At Dhond ○ Railway B. M. Station.	1693'296	1693'108	—'188	1692'41	

Approximate distance in miles from Bombay.	Name of Bench-mark.	OBSERVED HEIGHTS ABOVE MEAN SEA LEVEL 1876-77, IN FEET.		Difference with sign for new value against old.	Heights published in Pamphlet, in feet.	REMARKS.
		Seasons 1877-81.	Season 1906-07.			
183	G. T. S. At Diksal □ Railway B. M. Station.	1658'706	1658'507	—199	1657'72	
236	G. T. S. At Barsi- □ road B. M. Railway Station.	1678'540	1678'066	—474	1677'38	
286	G. T. S. At Shola- □ pur Rail- B. M. way Sta- tion.	1493'351	1492'526	—825	1492'07	
357	G. T. S. At Gul- ○ barga B. M. Railway Station.	1490'924	1489'987	—937	1489'50	
441	G. T. S. At Bridge ○ near Rai- B. M. chur Railway Station.	1288'655	1286'786	—1'869	1286'78	
472	G. T. S. At Kosgi □ Railway B. M. Station.	1239'957	1238'016	—1'941	1238'10	

The differences between the old and new levelling throughout the line from Bombay to Kosgi, are cumulative; no large individual error has been disclosed; on the section Gulbarga to Raichur, which shows the greatest discrepancy, the error is likewise of a cumulative nature.

The most probable source of error is taking long range shots at a time of day when the air is boiling and the radiation excessive. This source of error has been especially guarded against in the observations taken within the past few years.

The line Gulbarga to Raichur levelled in 1879-80, was done towards the close of the field season and traversed country which is undulating for the first 30 miles and flat and sandy for the rest of the length. It is possible that radiation was at times excessive whilst observations were being taken.

The average discrepancy per mile between Bombay and Raichur is 0.004 foot.

That between Gulbarga and Raichur 0.011 foot.

The closing discrepancy between the mean sea-level at Bombay and the mean sea level at Karwar, using the earliest values, was 0.93 foot, Karwar being higher than Bombay. The levelling route was Bombay, Kedgaon, Hubli, Karwar.

The closing error now obtained by the same route is 0.814 for Karwar, using the new value for Kedgaon.

By the line Bombay, Kedgaon, Gulbarga, Raichur, Bellary, Hubli, Karwar, the error now computed is 0.175 at Karwar, introducing the new value for Raichur.

This would seem to indicate a large error on the line Kedgaon to Hubli.

Levelling to Mussoorie was first done in April-May 1904.

Owing to the earthquake on 4th April 1905, the line was revised in April-May of this year.

The difference obtained at the terminal point, which is a Bench-mark at "Dunseverick," Vincent's Hill, was 0.468 foot, or $5\frac{1}{4}$ inches, the height determined in 1905 being lower than in 1904, showing apparent sinking of Mussoorie. As a portion of the line, Kolukhet to Mussoorie, was executed by single levelling, in May 1905, the difference in height obtained could not be finally accepted and it was therefore decided to revise this portion by double-levelling. This was done in October of the same year.

The general result showed an apparent sinking of Mussoorie of 5 inches instead of $5\frac{1}{4}$ inches.

With the object of testing this conclusion, the section Saharanpur to Dehra Dun was relevelled in April-May 1907, the levels starting from the embedded Bench-mark at Saharanpur and closing on a mark at the Dehra Survey Office, the identical mark from which the levels to Mussoorie emanated.

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Assuming the old Bench-mark at Saharanpur to be unchanged, the results of the present levelling seem to indicate that a gradual upheaval took place towards the Siwaliks. This is first noticeable at the embedded Bench-mark at Mohan (27 miles from Saharanpur). Unfortunately two old Bench-marks at Kailaspur and Bhatpura, 6 and 16 miles respectively, from Saharanpur, could not be found.

The following figures show the difference in height of Bench-marks along the line between the old and new levelling, the values of 1906 being higher than the old values :—

Saharanpur	0'000 foot
Mohan 27 miles from Saharanpur southern side of the Siwaliks	+0'330 "
Mohabawala 37 miles from Saharanpur northern side of the Siwaliks	+0'365 "
E. end Dehra 38 miles from Saharanpur Base Line	+0'394 "
Dehra Survey Office 44 miles from Saharanpur	+0'444 "

The difference found after the earthquake in the height of Mussoorie, accepting Dehra as correct, was —0'418 foot. By accepting Saharanpur as unchanged, we now find that Dehra appears to have risen by an almost equal amount.

Combining the results, if Dehra is said to be unchanged then Mussoorie and Saharanpur have both sunk by 5 inches; if Saharanpur has not been disturbed then Mussoorie may be said to remain unaltered and Dehra raised by 5 inches.

Attached is a diagram showing apparent vertical displacements between Saharanpur and Mussoorie.

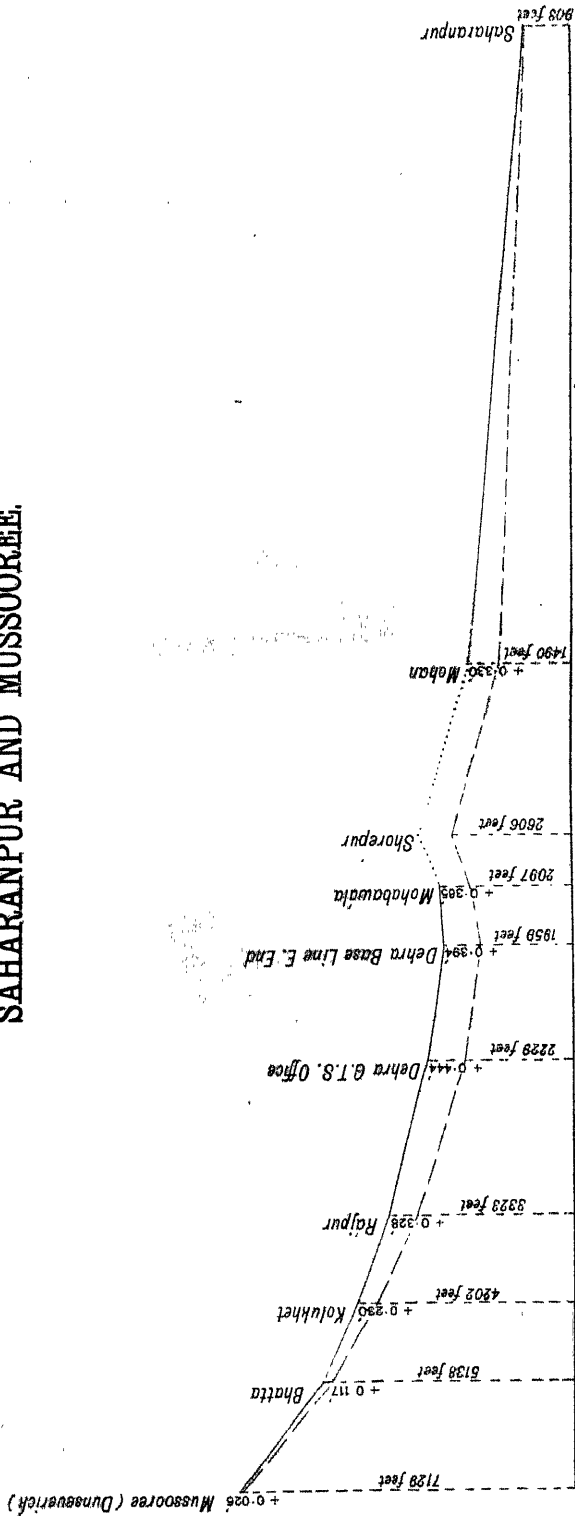
In the course of levelling operations in the Punjab, the Indus River was crossed by 3 distinct methods of levelling, these being (1) by means of the old tide-pole or water-gauge method. (2) By vertical angles. (3) By actual levelling of precision.

The place where the river was crossed was between Darya Khan and Dera Ismail Khan.

The time of year was late in December, when the width of the main channel was at its narrowest, being about $\frac{1}{2}$ mile.

The direct levelling was rendered possible by the fact that three or four little sand islands existed in the stream some distance below the place where the tide-poles were erected.

DIAGRAM SHOWING VERTICAL DISPLACEMENT BETWEEN SAHARANPUR AND MUSSOOREE.



Horizontal Scale 1 inch = 4 Miles
Vertical Scale 1 inch = 200 Feet
Vertical Displacement 1 inch = 1 Foot (shown thus +0.330)

NOTES
The Shorepur B.M. not having been found, a direct comparison with the top of the "elevated" could not be made, hence shown in diagram by dotted lines.
Old line of Levels shown in bars.

The values of difference of height obtained by the three methods are shown in the table below:—

By Tide-pole method.	By Vertical angles.	By actual levelling.
From forenoon observations. 1'201 feet	From forward angles . 0'938 foot	By First Leveller . 0'930 foot
From afternoon observations. 1'192 „	From back angles . 0'900 „	By Second Leveller . 0'922 „
Mean 1'197 feet	Mean 0'919 foot	Mean 0'926 foot

In December 1900 similar experiments were made on the Ganges River at Damukdia.

The distance across the river between the referring marks was 1'28 miles.

The result of the operations was that the difference of heights between the referring Bench-marks was found to be:—

By vertical angles 2'139 feet

By levelling 2'132 „

By water gauges 2'212 „

In 1856 the River Chenab was crossed by two methods (1) by means of tide-poles, (2) by direct levelling. The difference was '048 of a foot, the breadth of river being 12 chains.

The difference between results by tide-pole method and by levelling is thus:—

On the Chenab (1856) '048 of a foot.

„ „ Ganges (1900) '080 „ „

„ „ Indus (1906) '271 „ „

while the difference between the results by levelling and by vertical angles is—

On the Ganges + '007 of a foot.

„ „ Indus — '007 „ „

The above figures would seem to establish the superiority of the vertical angle method over the tide-pole method.

An American pattern level, known as the “Binocular Precise Level,” constructed after the design in use in the United States Coast and

Geodetic Survey, manufactured and supplied to this Department by George N. Sægmullar, Washington, United States, America, has for the first time been used by Indian Survey levellers during the past field season. The levellers found them to be light and handy little instruments and to fully bear out their reputation for accuracy and the attainment of speed in levelling.

Their employment involved certain alterations in Indian methods, the procedure adopted being a combination of the American and Indian systems.

Up to date the number of Standard Bench-marks completed is 41 ; of these 36 have been connected, 5 remain to be levelled to. The number under construction is 27. In all 68 have been dealt with. Arrangements are being made to continue the erection of Standard Bench-marks during the coming year.

GEOGRAPHY

BY

J. ECCLES, M.A.,

Officiating Superintendent, Trigonometrical Surveys.

In April 1906 Dr. Stein left India for Khotan to continue his archæological researches. He took with him a surveyor belonging to the Survey of India and has from time to time sent back traces of the topographical work done. The surveyor is returning owing to ill-health and another has been sent to assist Dr. Stein. When the first surveyor returns the work will be compiled.

BOTANICAL SURVEY

BY

CAPTAIN A. T. GAGE, I.M.S., M.A., B.Sc., M.B., F.L.S.,

Director, Botanical Survey of India.

Eastern India.—BENGAL.—Owing to the as yet unorganised and unstaffed condition of the Botanical Survey it was impossible to systematically devote special attention to any particular district in the

province during the year. In the circumstances it was considered better to send Indian collectors to bring in any special groups or families of plants. Thus one man was despatched to the Sunderbuns to collect examples—for distribution to European botanical centres—of such genera as *Sonneratia*, *Kandelia*, *Carapa*, *Ceriops*, *Heritiera*, etc., which exhibit peculiar morphological modifications to adapt them to life under such conditions as exist in the Sunderbuns. Another collector was sent to Western Bengal to collect roots of various species of water lilies, also for distribution to European botanical gardens. The usual collection of plants for the Herbarium and for distribution and of seeds from the high altitudes of the Darjeeling District and Sikkim for distribution to temperate regions of the globe was continued during the year. The Survey has also as in the past been indebted to the Rev. Father Cardon, S.J., of Chota Nagpur, for several interesting photo-geographical discoveries in the way of extensions of the area of distribution of certain species to that part of Bengal.

EASTERN BENGAL AND ASSAM.—In this province a collector was deputed specially to collect the Flora of the district of Mymensingh. Quite recently also Mr. Meebold, the gentleman mentioned in last year's report, has again gone to Manipur on a collecting tour from which the Botanical Survey is to benefit.

BURMA.—By the kindness of Mr. I. H. Burkill, M.A., F.L.S., Reporter on Economic Products to the Government of India, a collector was allowed to accompany him on his tour in the district of Arracan. The vegetation of this district is very imperfectly known, so that interesting results are anticipated when once opportunity of working up the collections occurs. As usual the officers of the Tenasserim Forest Circle contributed interesting and excellent specimens from Lower Burma, while the Deputy Conservator of Forests, Port Blair, contributed a small collection from the Andaman Islands.

Western India.—Mr. G. A. Gammie, the Economic Botanist to the Government of Bombay, has continued his studies of the *Orchidaceæ* of that Presidency, and has also written an account of the vegetation of Bombay Island for the Gazetteer. Mr. Talbot and Mr. Ryan of the Forest Department have continued their botanical work on the same side of India. Considerable collections have been made in Baluchistan by local officers, primarily to determine the economic plant resources of

the country. Those collections which are also of great general botanical interest have been worked out in the Herbarium of the Calcutta Botanic Garden by Mr. I. H. Burkill, the Reporter on Economic Products. A collection of plants, chiefly of economic interest, from Koweit collected by Captain Knox, the Political Agent there, and forwarded by Mr. J. G. Lorimer, I.C.S., C.I.E., has been worked out as far as the material allowed.

Southern India.—The Systematic Assistant to the Government Botanist worked out a large number of South Indian plants collected by Mr. Barber, the Government Botanist, who has been granted leave out of India. The same assistant explored for about three weeks the Nallamalais for root parasites and a general botanical collection, and during the tour discovered a new root parasite. He also worked out barks collected on the Anamalais and the grasses of South Canara, and contributed notes on various botanical subjects to the Reporter on Economic Products, to the Director of Agriculture for Madras, and other officers.

Mr. C. E. C. Fischer of the Forest Department has continued his excellent systematic work in Coimbatore and more recently in North Malabar.

North-West India.—The Herbarium of the Royal Botanic Garden, Calcutta, has been enriched during the year by collections from various parts of the North-West Himalaya made by Mr. I. H. Burkill, Mr. A. R. Tucker of the Imperial Revenue and Agricultural Department, Mr. A. Meebold, and Lieutenant-Colonel J. M. Carpendale, I.A.

From the North-West Frontier Province an excellent collection was presented by Mr. James Marten of the Forest Survey Department, the same officer who formerly did a great deal of work for botanical science on quite the other side of India.

The Survey is indebted to Sir Harold Deane, K.C.S.I., the head of the North-West Frontier Province, for several excellently preserved collections that are particularly interesting in that they show several instances of an eastward extension into India of species hitherto recorded only from the countries to the immediate west of India.

General.—Apart from work done in India systematic Indian Botany has benefited by the loan of Indian Herbarium material of several genera and orders of plants to botanists in Europe engaged in writing special monographs. Thus the Calcutta material of the genus *Arabis*

has been sent on loan to Professor Dietz of Buda-Pesth; of the genus *Bridelia* to Professor Pax of Breslau University; several genera of the natural orders *Amarantaceæ* to Professor Hans Schinz of the University of Zurich. Most of the Indian material of the natural order *Araceæ* is still with Professor Engler, Director of the Imperial Botanical Garden of Berlin.

The Rev. Father E. Blatter, S.J., has studied the interesting problem of the relation between flowering season and climate and has given his results in the Journal of the Bombay Natural History Society. Generally speaking the flowering season appears in the tropics to be practically independent of temperature, but roughly to vary inversely with the amount of humidity, at least in the case of woody plants. The maximum period of flowering of herbaceous plants, however, appears to be towards the latter end of the rainy season.

Mr. Burkill has given considerable attention to the modes of pollination employed by certain Indian plants, which he has described in the Journal of the Asiatic Society of Bengal.

Several physiological researches of interest from the point of view of Indian Botany have been carried out by workers in Europe, some of whom have been furnished with the necessary material from the Calcutta Botanic Garden. These researches are indicated in the list of publications appended to this report so that it is unnecessary to detail them here.

Publications.—Professor Radlkofer's paper on new Eastern Asiatic species of the natural order *Sapinduceæ*, which was referred to in last year's report, has since appeared as Part 3 of Volume III of the Records of the Botanical Survey of India. There is at present in the Press and almost ready to appear in the same publication a *Revision of the Indo-Malayan Species of Cedrela* by M. C. de Candolle, the distinguished botanist of Geneva.

In the Annals of the Royal Botanic Garden, Calcutta, has appeared a systematic monograph on the *Orchids of the North-West Himalaya* by Mr. J. F. Duthie, B.A., F.L.S., formerly Director of the Botanical Department of Northern India and now at Kew. This monograph forms Part II of Volume IX of the Annals and comprises descriptions of all the orchids of the North-West Himalaya with keys to facilitate identification and fifty-eight plates of those species which are not or only imperfectly figured elsewhere. The "*Descriptions of new species*

of *Algæ from Burma*” by Mr. W. West and Professor G. S. West and Signor Beccari’s monograph on the genus *Calamus* are still, it is to be regretted, in the Press. The former, however, is practically ready to appear. Another number of Dr. Cooke’s Flora of the Bombay Presidency has appeared which brings his work down to the end of the natural order *Euphorbiaceæ*, while a further instalment of Mr. J. F. Duthie’s Flora of the Upper Gangetic Plain has been sent to Press.

No. 19 of the “Materials for a Flora of the Malayan Peninsula” by Sir George King and Mr. J. S. Gamble has appeared during the year. This number comprises descriptions of the genera and the species belonging to the natural orders *Apocynaceæ*, *Asclepiadaceæ* and *Loganiaceæ*.

Several other botanical publications, some of very considerable importance, are referred to in other sections of this report which deal with botanical science from other sides than that of purely survey work. The list of papers appended should give a fair idea of the nature and scope of purely botanical work bearing on Indian botany done during the year either within or outside India.

A list of papers bearing on the Botany of India published during 1906-07.

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AGRICULTURAL BOTANY

BY

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Foods.—The botanical study of the cereals mentioned in the last report—wheat, juar, rice and barley—has not yet reached the stage of publication but is still in progress. No publications of botanical importance have been issued in connection with Indian cereals during the year. Agricultural Ledgers on the races of juar and on the rice, *Oryza coarctata*, are promised shortly by Mr. Burkill, Reporter on Economic Products. Mr. Howard, Imperial Economic Botanist, has a large monograph of Indian wheats under preparation. This is based on representative collections grown and isolated at Pusa and Lyallpur, as typifying the Eastern and Western Indo-Gangetic areas, extended by field observations in other tracts. The classification of Indian wheats is completed. A number of successful crosses have been obtained at Pusa and Lyallpur, and wheat-breeding work is proceeding at these stations on Mendelian lines. The botanical enquiry into Indian barleys has been made over by the Reporter on Economic Products to Mr. Howard, who has commenced the preliminary work at Pusa.

Mr. Barber has continued his work on sugarcane in South India. Special attention has been paid to the origin of sugarcane varieties. An account of their origin by "sporting" or bud-variation, in certain cases observed at the Samalkota Farm, has been published. Some of the sports have proved of exceptional quality and have been segregated and cultivated. They have originated only from striped canes, and this is held to indicate that the striped varieties are in reality hybrids between two canes of different colours. At the last meeting of the Board of Agriculture the whole question of the improvement of the Indian sugarcane industry was discussed. A number of papers on the

subject was laid before the Board, and from these it may be gathered that, although the agricultural characters of Indian sugarcane have been investigated in some provinces, notably by Khan Bahadur S. M. Hadi in the United Provinces, no real botanical work with them has yet been attempted in this country. Though seedling canes have actually been raised, they have never reached the experimental stage, and this immensely important line of work has yet to be undertaken in India. Individual selection for yield and quality of juice is another promising direction awaiting attention. The ground has, however, been cleared for future work, as soon as the botanical staff becomes strong enough to undertake it.

The reports on Indian yams, caraways and Burmese pulses, referred to in last year's report, are still in preparation; enquiries are also being continued regarding chillies, pan (Piper Betel), plantains and kessary (*Lathyrus sativus*) by the Reporter on Economic Products.

Mr. Burkill has published a Ledger on Goa beans (*Psophocarpus tetragonolobus*), which gives the history, distribution and characters of the pulse in India. Another Ledger has been written by Mr. D. Hooper on the food value and uses of the root of *Costus speciosus*. The identity of the common root of the Calcutta market called "Singapuri kesur" was determined by Mr. Burkill, who has found it to be the root of *Eleocharis tuberosa*, the Chinese "Pe-tsi" or "Ma-tai."

A series of experiments designed to throw light on the behaviour of Indian fruit trees under different conditions and treatment has been initiated by Mr. Howard at Pusa. A first report on these has been published, giving details of the main lines of work.

Fibres.—A large and important work on the cottons of the world by Sir G. Watt is announced. The memoir on Indian cottons by Professor Gammie, referred to in last year's report, is now in the Press. Mr. Fletcher, Deputy Director of Agriculture, Bombay, has published a preliminary note on Bombay cottons. From this it appears that considerable progress has recently been made in introducing exotics, especially Egyptian cotton, in Sind. Sea Island cotton of good quality was grown at Karachi in 1906. Tree cottons of the "rough Peruvian" (? *G. peruvianum*) and Bourbon (? *G. barbadense*) types are being grown in the Karnatak and Ahmedabad-Kaira tracts, respectively. A large collection of tree cottons is maintained at Poona for botanical investigation by Professor Gammie, who has prepared a preliminary

classification of the main types. Mr. Fletcher records that at least one extremely promising hybrid cotton has been reared on the Surat Farm, and remarks that this hybrid, No. 1027 A, will, if it preserves its good qualities, be worth many times more than the whole expenditure on the Surat Farm since its commencement. A memoir on the cotton known as *Gossypium obtusifolium* Roxb. has been published by Mr. Burkill, and the same author has furnished a note on the pollination of the cotton plant, which tends to confirm the conclusion previously reached by Professor Gammie, that cross-fertilization and natural hybridization are rare in cultivated members of this genus.

A review of the Indian Agaves has been published by Mr. J. R. Drummond and Lieutenant-Colonel Prain, as Agricultural Ledger No. 7 of 1906. The more important features of this work, from our point of view, are the following. *Agave americana* is apparently not a naturalized plant in any part of India, but is merely grown in gardens as an ornamental plant. It disappears therefore as a name for any plant yielding commercial fibre in India. Where *A. americana* has been spoken of in previous Indian literature some other species is almost always intended. This is often *A. Cantala*, which gives good fibre and is largely exported, mixed with others, as "Bombay aloe fibre." All told ten species have been separated in the course of this enquiry, of which six are identified and the remaining four are not at present identifiable owing, in great measure, to the extraordinarily confused condition of the literature on the subject. Besides *A. Cantala* three other species are of economic importance in India according to present knowledge, *vis.*:—*A. sisalana*, a comparatively recent introduction, *A. Wightii*, which has the disadvantage of being short leaved, and an unidentified species called temporarily by the authors *A. "species F."* Three, *A. americana*, *A. decipiens* and *A. "species C."* are only known in India as ornamental plants or in herbaria as dried specimens. One, *A. "species A."* has only been obtained during the enquiry from Burma, but is probably cultivated at the Saharanpur Botanical Garden. Of the remaining two nothing is really known about the fibre, but *A. "species H."* is the finest plant of the naturalized species, with leaves 7 or 8 feet long, is widely distributed and, it is believed, would repay careful investigation; while *A. Vera Cruz* is less likely to be profitable. Further, two species of plants yielding Mauritius hemp occur in India, where previously but one (commonly called *Furcræa gigantea*) was

sion arrived at after a survey of the various trials is in agreement with the opinion expressed by Lieutenant-Colonel Prain, recently Director of the Botanical Survey of India, that there is much more promise in the extension of indigenous salt bushes and other plants than in trials of exotics.

Mr. Fletcher, recently Deputy Director of Agriculture, Bombay, has carried out a series of experiments tending to show that the roots of plants excrete an auto-toxic substance during growth. A memoir giving details of the work is in the Press.

Mycology and plant pathology.—An account of the "red rust" of tea caused by the interesting alga, *Cephaleuros virescens*, was published by Dr. H. Mann and Mr. C. M. Hutchinson, of the Scientific Department of the Indian Tea Association. This is a technical account of the authors' work, the chief practical results of which have already been published.

The first part of a series entitled "Fungi Indiæ Orientalis" has been issued by Messrs. H. and P. Sydow of Berlin in conjunction with the writer. This contains technical descriptions with notes of 143 species of parasitic rusts and smuts, of which one genus and 42 species are new to science. A second instalment, completing these groups as far as they are represented in the Pusa Herbarium and including the *Phycomycetes*, in all about 200 species, has been worked out and will shortly be published. This is the first attempt at a systematic account on a large scale of the Indian fungus flora. The monograph on the *Pathiaceæ* referred to last year has been published. The chief species of economic importance in India is *Pythium palmivorum*, a destructive parasite of palms. A more popular account of the disease caused by this fungus and some other palm diseases was published in the "Agricultural Journal of India." Operations in its prevention are in progress in the Godavari Delta, under a special establishment sanctioned by the Government of Madras.

A curious group of cereal diseases, producing floral malformations and sterility in several important crops, was studied and its cause ascertained to be the parasitic Phycomycete, *Sclerospora graminicola*. An account of these diseases, which may at any time become epidemic, was published. Attempts to raise wilt-resisting varieties of pigeon-pea are in progress at Poona, and are promising well. Treatment of the ticca disease of ground-nut by spraying and steeping, at the same

locality, has proved unsatisfactory, and the only hope of reducing the losses caused by this disease appears to be the raising of early maturing and resistant varieties. Work is well advanced on the group of wilt diseases in India caused by *Neocosmospora vasinfecta* and affecting cotton, pigeon-pea, gram, indigo and other crops. The full investigation will take some years to complete. Another troublesome investigation, as yet incomplete, is that of an orange disease prevalent in Sylhet and Burma. Work with sugarcane diseases, wheat and other rusts, and a number of other crop diseases, was continued by the writer.

The trials of the South African Locust fungus carried out by the writer in conjunction with the Imperial Entomologist were completed and a report issued. This much-vaunted method of destroying locusts has proved absolutely useless. Recent work in South Africa itself gives a sufficient reason for this. The fungus distributed by the South African authorities (and which was employed in India) has been ascertained to be quite different to the actual locust parasite, and is probably an accidental contamination from the first prepared tubes. This fact escaped detection until now, owing to the absence of any mycologist on the spot until recently. It is doubtful if the true locust parasite in the Transvaal can be artificially cultivated, but attempts are being made on the spot, and, if successful, the work can be repeated under better auspices in India.

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- E. J. BUTLER.

FOREST BOTANY

BY

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Anatomy.—1. The most important research under this head, dealing with Forest Botany carried out during the year, is that comprised by Dr. Barber's investigations into the haustoria of Sandal.¹

Forest Floras.—2. By far the most important publication issued during the year is that entitled *Indian Trees*. This comprehensive

¹ Memoirs of Department of Agriculture in India, Botanical Series, Vol. i, No. i, Part ii.

work will be the standard book of reference for Forest Officers for many years to come and will be of the greatest use in the preparation of local forest floras which was one of the chief of the author's aims in its compilation.

Mr. Haines was engaged during the year on the preparation of the Flora of Chota Nagpur. A preliminary list of the trees, shrubs and climbers found in the Northern Circle of the Central Provinces, by the writer, was published by the Local Government during the year.

Mr. Witt was engaged during the year on the preparation of a list of species found in the Berar Circle of the Central Provinces, based on the list originally prepared by Mr. Dickinson and added to by Mr. Ballantyne.

3. A paper dealing with the possibility of adopting a generally acceptable definition of the word species was contributed by the writer during the year.¹

Limitation of Species.

Culture experiments, carried out for the purpose of testing the validity of the claims of particular plant forms to rank as species, are unfortunately difficult in the case of trees, owing to the long periods of time required, but it seems probable that good results would be obtained if more attention were paid to the careful study of large sets of specimens, each set having been collected from one and the same individual tree. In last year's report the remarkable dimorphism of the twigs and leaves of *Populus Gamblei* was alluded to. A silvery-pubescent form of *Anogeissus latifolia* is also not uncommon which, when first seen, might be held to be a distinct species, but the writer has found branches of this variety on a tree of the ordinary type.

4. Sir D. Brandis has a note on an undetermined species of *Picea* found in Sikkim and the Chumbi Valley.²

New Species.

Captain Gage has a paper on the varieties of *Bombax insigne* Wall.³ *Populus glauca* Haines mentioned in last year's report has been noticed by Messrs. Arber and Parkin in their interesting paper

¹Journal of the Bombay Natural History Society, Vol. xvii, No. 4, p. 930.

²Indian Forester, Vol. xxxii, p. 579.

³Indian Forester, Vol. xxxiii, p. 115.

on the origin of the Angiosperms.¹ The frequent occurrence of bisexual flowers and of an undoubted perianth in this species are held to indicate that *Populus* is the older genus and that *Salix* has probably been derived from a Poplar-like ancestor.

5. Mr. B. B. Osmaston reports that a forest herbarium has been started in the Andamans, a large number of specimens of the trees and shrubs of the Andamans, collected both by Mr. Osmaston and his predecessors, having been classified and properly arranged in glazed almirahs obtained from Sibpur.

Mr. Osmaston has also very kindly sent 260 duplicate sheets for incorporation in the herbarium of the Imperial Forest College at Dehra Dun. A considerable amount of work was done in the latter herbarium by the Forest Botanist during the year. Up to the date of this report some 700 sheets have been added, among the principal contributors being Messrs. Haines, Lace, Osmaston, Haslett, Witt, Modder, Long and Keshavanand. The identification of all specimens received by the Forest Botanist were communicated where necessary and help was afforded to the compilers of local lists.

Mr. D. A. Thompson has made a collection of the grasses found in the forests of Panch Mahals.

A reference collection of wood specimens was commenced for the Museum of the Forest School at Balaghat, Central Provinces, and Mr. Clutterbuck has started a similar collection for the Kheri Division.

6. Observations on the distribution of important forest species in the various districts and divisions are greatly needed. And no doubt Forest Officers will afford valuable assistance in collecting data on this point so that maps showing the detailed distribution of the various species may be prepared in the Forest Research Institute. Until this has been accomplished discussions regarding the factors which influence the distribution of Indian trees must remain to a great extent profitless.

Interesting, from the point of view of distribution, are the finding of *Mastixia Euonymoides* Prain, in British Bhutan,² of *Vitex*

¹ Journal Linnean Society, Vol. xxxviii, p. 41.

² Indian Forester, Vol. xxxiii, p. 57.

glabrata by Mr. Haines in the Sonthal Parganas and of a species of *Berberis* wild on the hills near Pachmarhi by the writer.

7. Mr. Cubitt reports interesting instances from the Bhamo

Periodicity.

Division, Burma, in which young teak trees with a fairly advanced new flush of leaves have been found in May, growing side by side with old trees on which there were still large numbers of vigorous old leaves. The factors which influence the periodic shedding of leaves and the production of new foliage in our Indian trees require careful investigation. In some cases the temperature and in others the moisture of the soil appears to exercise the most important influence, while it has been noticed that deciduous species in a forest which has been burnt over frequently come into leaf earlier than elsewhere. The whole question is connected more or less closely with the formation of annual rings of growth and the quality of the wood and is therefore of importance.

As regards annual rings, Mr. McIntire (Conservator, Bengal) reports interesting results of experimental ring countings on sections of Sal coppice shoots, 10½ years old, in the Sonthal Pargana Division which "proved that the ages of such shoots in dry localities could be accurately determined by counting these rings." Mr. McIntire also notes that "observations of rings on fresh cut stumps in the Kurseong Terai (climate very damp) appeared to show that the rings accurately show the ages of trees in that locality, at any rate until they are 60 to 100 years old."

8. The subject of reproduction being of such great importance in

Asexual Reproduction.

Forestry considerable attention has been paid to it by Forest Officers generally.

The writer contributed a paper on Coppice Shoots¹ in which the necessity is emphasized of distinguishing between, first, those cases in which the young shoots develop a root-system of their own and become independent of the parent, as often occurs apparently in the case of root-suckers and also possibly in the case of some stool-shoots, and secondly, those cases in which the young shoots are entirely dependent on the parent stump, as is the case with pollard-shoots. In the first we are dealing with cases of more or less complete reproduction and

¹ Indian Forester, Vol. xxxii, p. 334.

in the second with cases of more or less complete recovery of one and the same individual from a severe injury.

An important point in coppice forests is whether or not the "coppice-shoots" are able to produce fertile seed. Experiments carried out by Messrs. Tulloch and Gulab Rai in the Bahraich and Gonda Divisions of the United Provinces, so far as they go, indicate that the seed of *Sal* coppice shoots is fertile, but the results of these experiments will, it is hoped, soon be published in detail. Meanwhile, the following small experiment conducted by the writer during the year while on leave in England, may be mentioned as being of interest, although it refers to the European species *Quercus pedunculata*. Some 40 acorns were collected at random from a seedling tree and a similar number from coppice stems, and from each batch 15 of the best were sown. Of each set of 15 acorns, 14 germinated and produced healthy plants and there was one failure. This case is noticeable because the coppice stems were obvious stool-shoots with no independent root-system. They were only eight feet high and about eight years old, but they sprang from a very old stool which was in great part decayed, and their acorns were fully fertile. Further observations on our Indian species referring to the different types of shoots are badly needed. Whatever the disadvantages of asexual reproduction may be, the fact should not be forgotten that it usually produces plants which, at all events at first, grow more vigorously and attain large dimensions quicker than do those developed from seed. This power of vigorous growth may often be of vital importance for the existence of the plant, *e.g.*, in areas which become quickly covered with a heavy growth of grass, in which the slow-growing young seedlings of forest trees are often smothered and killed, whereas strong-growing root-suckers may be able to establish themselves. Evidence that this has happened is afforded in many parts of India where practically pure forests of *Ougeinia dalbergioides* and *Diospyros tomentosa* (both species which produce root-suckers freely) now occupy the sites of abandoned fields.

Mr. McIntire notes that "other things being the same, coppice reproduction is far less satisfactory in the damp climates of the terai and of the Darjeeling hills than in the relatively dry climates of Chota Nagpur, Orissa, etc. In the damp climates cutting so as to leave stumps a few inches high seems to be more favourable for coppice reproduction than cutting level with the ground."

Mr. Clutterbuck has also noticed that "Sal, cut level with the ground and the stumps dressed, gives very poor results in the way of coppice shoots. In fact the greater proportion of trees above one foot in girth give no shoots at all. This appears to be due to the contraction of the wood (Sal being particularly liable to such shrinkage) causing the wood near the surface of the stump to part from the bark. The cambium is in this way killed to a depth of three or four inches below the ground. The dormant buds appear to exist chiefly in this region, and thus no shoots appear. It is probable that this could be remedied by cutting the trees about four inches above ground. The portion above ground then would dry up and coppice shoots would be produced in abundance from ground level."

9. Mr. Pearson contributes an interesting paper on *Anogeissus latifolia*¹ and comes to the conclusion that this species rarely produces large quantities of fertile seed except under unusual conditions, e.g., after drought.

In addition to the climatic factors which influence the production of fertile seed, observations are badly needed, regarding the methods employed by our forest species to ensure the fertilisation of their flowers. It is possible that the failure to produce fertile seed may in some cases be due to the failure to secure cross-fertilisation, and if so it is possible that we might do something to help the birds or insects which are instrumental in securing cross-fertilisation and thus good crops of fertile seed.

Mr. Clutterbuck notes that it was a record year for an abundance of Sal flower and seed and draws attention to the coincidence of there being unusual falls of rain in February, March, April.

10. Mr. Monro has made some observations on the damage done by *Trametes pini* in the forests of *Pinus excelsa* of the Simla Division. Trees which have been lopped or wounded are mainly attacked and the fungus can apparently only attack a healthy tree through the medium of a wound unprotected by resin, as is the case in Europe. Mr. Rogers (Conservator, Berar) reports that *Fomes Pappianus*, which at one time was believed to be doing serious damage to the Babul (*Acacia arabica*)

¹ Indian Forester, Vol. xxxiii, p. 231.

forests of Berar, is no longer giving cause for anxiety. Mr. Rogers also notes that Anjan (*Hardwickia binata*) seedlings are particularly liable to damage by grazing, owing to the fact that the young leaves appear in the hot season when fodder is scanty. The seedlings which survive in grazed areas are usually protected by armed shrubs, such as *Zizyphus* sp.

Although the damage done by plant parasites appears happily to be comparatively small, the great injury inflicted by plant competitors is becoming more and more prominent. Messrs. McIntire, Lovegrove and E. M. Coventry have alluded to the injurious competitive effect of the inferior species often associated with Sal.

The competition between tree species and grasses is severe and particularly so during early youth, owing to the fact that so many of our valuable forest species, for the first few years of their existence, only show a very insignificant development of the shoot above ground and have little chance of surviving in the struggle for existence with a dense growth of grasses which effectually shuts out the necessary light.

With the object of helping the tree species two plans are not infrequently resorted to:—

- (1) The sowing of tree seeds with low-growing field crops, the injurious competitive action of which is less injurious than that of grasses, while the cultivation prevents the development of the grasses.
- (2) Keeping down the grass-growth by grazing.

Mr. L. S. Osmaston contributes an interesting account of successful operations of the first class,¹ and regarding the second plan Mr. Rogers has an interesting note on the Babul forests of Berar. In his opinion there is no doubt that regulated and light grazing of cows and bullocks from the beginning in areas sown with this species is beneficial in helping the seedlings to establish themselves, by keeping down the growth of competing grasses and other weeds. The Babul seedlings appear to be protected to a great extent by their spines from injury by the cattle.

11. Dr. Mann has published a paper, on the cultivation of the rubber tree, *Hevea brasiliensis*, in Cachar,² on an approved system of tapping for rubber³

Economic.

¹ Indian Forester, Vol. xxxiii, p. 265.

² Agricultural Journal of India, Vol. ii, Part iii, p. 273.

³ Agricultural Journal of India, Vol. ii, Part iii, p. 277.

and on the general question of the commercial prospects of the rubber of *Ficus elastica*.¹

In the South Thana Division of Bombay, cultivation of *Hevea brasiliensis*, *Castilloa elastica*, *Ficus elastica* and *Manihot glaziovii* was started on a small scale with fairly satisfactory results.

A considerable number of specimens was collected by Forest Officers during the year for the Reporter on Economic Products.

12. Mr. Hill has a paper on the acclimatization of *Swietenia Mahagoni* in India,² Mr. C. E. C. Fischer

Miscellaneous.

has two papers, one on the patches of evergreen forests known as "sholas" in North Coimbatore,³ and the other on host plants of *Loranthaceæ*.⁴ Mr. F. H. Todd has an interesting paper on the forests of *Pterocarpus dalbergioides* in the Andamans,⁵ and Mr. Ellis on the flowering of *Cephalostachyum pergracile*.⁶

FOREST PRODUCTS

BY

R. S. TROUP, F.C.H.,

Imperial Forest Economist.

Forest Research Institute.—Since the inauguration of the Imperial Forest Research Institute at Dehra Dun a commencement has been made with several important investigations connected with Forest Economic Products, the results of some of which, it is hoped, will be published shortly. The chief of these investigations deal with the utilization of the less well-known Indian timbers, the suitability of others for special industries such as the manufacture of matches, tea-boxes and lead-pencils, while the demands of the market for railway-sleepers and paving-blocks is receiving attention. The seasoning qualities of different woods are being studied, particularly as regards the percentage of contained moisture, and among minor forest

¹ Agricultural Journal of India, Vol. i, Part iv, p. 390.

² Indian Forester, Vol. xxxiii, p. 308.

³ Indian Forester, Vol. xxxii, p. 481.

⁴ Indian Forester, Vol. xxxiii, p. 353.

⁵ Indian Forester, Vol. xxxii, p. 581.

⁶ Indian Forester, Vol. xxxiii, p. 323.

products the most practical methods of cultivating lac, and the present market conditions of cutch; oil seeds of forest trees and other products are receiving attention. Experimental cultivation of *Podophyllum Emodi* is also being carried out.

Strength Tests of Indian Timbers.—Much useful work on the testing of Indian timbers has been carried out during the past few years by Professor Everett of the Sibpur Engineering College with wood specimens supplied by the Forest Department. The results are embodied in Mr. Everett's "Memorandum on Mechanical Tests of some Indian Timbers" (Forest Bulletin No. 6, 1906), and show figures for shearing, crushing and bending tests, as well as for stiffness from bending, in respect of 398 wood specimens comprising 38 different species of Indian trees. From a comparison of these results with those published by Professor Unwin in regard to 87 wood specimens from various British Colonies, and those of tests made on 32 American timbers under the direction of the United States Government, it appears that Indian timbers hold the first place as regards shearing and bending strength and are not excelled in stiffness.

Effect on Timber of the Tapping for Resin.—Further tests of the relative strength of tapped and untapped pine trees (*Pinus longifolia*) were carried out during the year, the results of which confirm those of the previous year and agree with those made in America, namely, that tapping does not weaken but if anything strengthens the timber, while as to durability and immunity from insect attack the removal of resin makes little or no difference. The matter is of some importance in India where *Pinus longifolia* timber is much used by right-holders in the hills, and may later on form a considerable article of export.

Tapping Pine Trees on the Skew and on the Straight.—An interesting experiment, instituted by Mr. W. H. Lovegrove of the Forest Department in the *Pinus longifolia* forests of the Naini Tal Forest Division, has been in progress since 1904. One hundred selected trees were tapped by vertical blazes, and the same number of similarly situated trees by blazes running at an angle of 15 degrees. The result of three years' tapping shows that the latter produced 15.7 per cent. more crude resin.

Lac.—Investigations into the life history of the lac insect and the best methods of propagating and harvesting lac have been in progress

during the year, particularly in the Southern Circle of the Central Provinces. In the Bhandara Division, where the lac is sown on *Butea frondosa*, *Zizyphus Fuzuba* and *Z. Xylopyrus*, it has been noticed that the insect is most successfully cultivated on the first named species, which shows a preference for black cotton soils, also that the grazing of goats is beneficial to the spread of this tree whose foliage they avoid while enjoying that of its associates. It has also been noticed that light rainfall during the time when the insects swarm would appear to be favourable to their establishing themselves successfully.

Tans.—A detailed report has been received on the tanning properties of extracts of the barks of *Terminalia tomentosa*, *Shorea robusta* and *Rhizophora mucronata* (Mangrove) prepared by Professor Dunstan's decolorising process by the Forest Department at Rangoon Tannin Factory. The first trials of this process may be considered satisfactory, although sodium bisulphite was used instead of the metabisulphite recommended, and afford hope that the extracts of *Shorea robusta* and *Terminalia tomentosa* may later on find a ready sale in India, provided that bark is used from trees which are not too old, that the decolorising process suggested is employed, and that great care is taken in the evaporation of the extract. As regards the extract of *Rhizophora mucronata*, there is no reason why this extract should not find a place in the home markets when it becomes better known. The Tannin Extract Factory in Rangoon is now closed as it is considered that enough has been done to prove the practicability of the manufacture on a commercial basis of this commodity in India.

Samples of tannin extract prepared by the District Forest Officer of South Canara from the wood of *Xylia dolabriformis* were found to contain 71·2 per cent. and 77·5 per cent. of tannin. The amount of tannin present is satisfactory, but the amount of colouring matter in the extract greatly reduces its value.

Experiments made in England with the "kino" of *Pterocarpus Marsupium*, prepared by the Madras Forest Department, showed that although this substance, in conjunction with sodium metabisulphite, possesses good tanning properties, its cost is too high as compared with other equally suitable tanning agents.

Rubber.—Further samples of Assam rubber (*Ficus elastica*) sent

to the Reporter on Economic Products have been analysed, with the following results:—

	Moisture.	Caoutchouc.	Resins.	Ash, etc.
Poona . . .	13'20	76'00	9'25	1'55
Ganjam . . .	3'7	85'20	7'8	3'3
Kulsi (Assam) . . .	0'7	78'00	19'0	2'79
Ditto . . .	2'1	80'00	16'00	3'84
Charduar (Assam) . . .	0'9	76'67	19'2	4'10

The high percentage of resin from the Assam specimens would appear to show either that the trees have not yet reached a sufficient age for producing the best rubber or that some unknown factor influences the quality of rubber from the Assam plantations.

The latices of some other species of *Ficus* were submitted to examination, but none were found to yield rubber in any quantity, the amount of rubber varying from 5 per cent. in *F. glomerata* to 31 per cent. in *F. tomentosa*.

Samples of the rubber of *Parameria glandulifera* from Burma and the Andamans were found to contain 91'8 and 91'6 per cent. of caoutchouc, respectively; both samples were reported to be good rubbers. Owing to the difficulty and therefore high cost of collection, however, it is doubtful if this rubber will ever reach much economic importance.

A sample of Para sheet rubber (*Hevea brasiliensis*) from the Mergui plantation was reported by Professor Dunstan to be equal in value to the best Straits rubber.

Though the Research Institute will still continue to receive and report on samples of rubber, it should be noted that this industry, which in its initial stages received so much assistance from the Department, is now established in India, and that the Government plantations are now offered for sale or lease, so that further experiments with regard to the cultivation of known species are not considered necessary.

Botanical and other specimens.—Numbers of botanical specimens, as well as timbers and miscellaneous forest products, were collected by the Forest Department and supplied to the Reporter on Economic Products, the Director of the Botanical Survey of India, the Industrial Exhibition, Calcutta, the Government Central Museum, Madras, and other Institutions, including Harvard University, America. Specimens of certain grasses were supplied to the Economic Botanist, Bombay.

Seeds.—The seeds of many Indian species were, as in former years, supplied to British Colonies and Foreign countries for experimental

propagation. Seeds of several Himalayan species, as well as *Dalbergia Sissoo* and *Ficus infectoria*, were sent to the Forest Department, Orange River Colony. The Transvaal was supplied with deodar seed. Seed of *Ficus elastica* from Eastern Bengal and Assam was sent to various firms, officials and individuals.

List of publications.

- EARDLEY-WILMOT, S. . Notes on the Influence of Forests on the Storage and Regulation of the Water-Supply.—Forest Bulletin No. 9.
- HOOPER, D. Acacia Catechu.—Composition and trade forms of Indian Cutch.—Agricultural Ledger No. 3, 1906.
- HOOPER, D. Costus speciosus.—Uses and value of the root as a food-stuff.
- SURENDRA NATH DEY . Cochlospermum Gossypium.—A short account of the seeds and oil.
- EVERETT, W. H. Memorandum on Mechanical Tests of some Indian Timbers.—Forest Bulletin No. 6.
- COVENTRY, E. M. Ficus elastica.—Its Natural Growth and Artificial Propagation. Forest Bulletin No 4.
- BALD, C. The Cultivation of Ficus elastica.
- TROUP, R. S. Indian Forest Utilization.

THE PROGRESS OF INDIAN ZOOLOGY, 1907

BY

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Owing to causes into which it is unnecessary to enter, it has been impossible to carry the present report beyond the end of August, but next year's report will commence from that date. In my general survey I have not dealt with questions affecting Agricultural or Forest Entomology or Veterinary Parasitology, as supplementary reports are submitted by the officers directly concerned with the study of these branches of applied Zoology.

I.—The work of the Natural History Section, Indian Museum.

Survey of the Invertebrate Fauna of Stagnant water.—Additional collections of microscopic freshwater animals have been made in Calcutta, Eastern Bengal, the United Provinces and the Simla Hill States by the Superintendent and the Museum Collector, and have been sent for determination to Prof. von Daday of Buda Pesth, while a large number of specimens of aquatic and semi-aquatic insects have been obtained from the same districts. The aquatic Hemiptera have been sent to Mr. W. L. Distant for description in a supplement to his volumes on the order in the "Fauna of British India," the Chironomidæ (Midges) to the Abbé Keiffer in Germany, and the Neuroptera to Prof. Needham in the United States, while arrangements are being made regarding the working out of the aquatic beetles in France. The Anophelinæ among the mosquitoes have been identified in the Museum, while the Culicinæ will be identified in England by Mr. Theobald.

The work has not, however, been confined to the collection of specimens and their transmission abroad for identification, for investigations have been made into various obscure points in the structure and biology of the freshwater sponges (of which several new species have also been described), such as the process of budding, the nature of the inhalent pores, commensalism and the production of gemmules.

Even more important than the fauna of freshwater ponds is that of the brackish pools in the Ganges delta, especially in the neighbourhood of Port Canning. Large collections have been made in such ponds, and I hope shortly, with the aid of the Rev. T. R. R. Stebbing, Dr. J. G. de Man, Mr. E. A. Smith, Mr. W. L. Distant, Col. Godwin Austen, M Régimbart and Prof. von Daday, to publish a complete fauna. It has been possible, thanks to the work done nearly forty years ago by the late Dr. F. Stoliczka, of the Geological Survey of India, to trace a very rapid and extraordinary change in the structure and habits of a sea anemone (*Metridium schillerianum*) which occurs in certain brackish ponds of recent origin at Port Canning, while the other elements in the fauna to which this remarkable species belongs have proved of great biological interest.

Survey of the Himalayan Fauna.—Special attention has been paid during the year to the lizards, Hemiptera and two-winged flies of

the Himalayas, collections having been made by the Museum Collector in Nepal and the Darjiling district and by the Superintendent in Kumaon and the Simla Hill States. The less obscure Hemiptera obtained have been identified by the Special Entomological Assistant ; many of the Diptera by Mr. E. Brunetti, who has been employed by the Trustees of the Museum to arrange the collection of Diptera ; and the lizards by the Superintendent.

As regards the lizards, two new species have been discovered and, what is more important, the distribution of the common forms has been considerably elucidated. It is interesting to note, as illustrating how little is known of the Indian fauna, that the late Dr. Blanford, the greatest authority on the distribution of the Indian vertebrates, was ignorant that the genus *Calotes* occurred in the Himalayas, although the common "bloodsucker" (*C. versicolor*), which is extremely common all over the plains of India, is almost as common in Darjiling and Kumaon as it is in Calcutta.

Many of the more conspicuous Himalayan Hemiptera collected during the year and already identified are proved to have a much more extensive range to the west than was previously known, evidently forming part of a Malayo-Himalayan fauna widely distributed in the Malay Peninsula, Burma and the Himalayas.

The collections of Himalayan Diptera, on the other hand, show that Palæarctic representatives of this order occur not only in the western but also in the eastern districts at comparatively low elevations. This is particularly noticeable as regards the Syrphidæ (hover flies), many of which are identical with common British species.

Survey of the Insects of Calcutta.—A collection of the insects of Calcutta and the immediate neighbourhood is in progress under the superintendence of the Special Entomological Assistant, particular attention being paid to the Diptera and to those groups on which volumes in the "Fauna of British India" are being prepared in London.

The regularity with which the species of many of the groups reappear week after week among the specimens brought to the Museum shows that in some groups (notably the Jassidæ and Fulgoridæ) the collection is already approaching completion. It is hoped that it may be possible before very long to begin the publication of an insect

fauna of Calcutta, giving the dates of occurrence and other particulars as regards each species.

Survey of the Rats of India.—Important pioneer work on this survey has been done by the publication of Dr. W. C. Hossack's memoir on the rats of Calcutta, and also by the issue of a smaller pamphlet by the same author in which directions are given as to the collection and preservation of specimens of the Muridæ. Rats are already beginning to arrive at the Museum from different parts of India, the Government of India having distributed Dr. Hossack's pamphlet with a strong recommendation that specimens should be collected and forwarded to headquarters. The chief points in Dr. Hossack's work have recently been confirmed by the independent investigations of Captain Gourlay, of the Indian Medical Service, in Dacca; but Captain Gourlay has shown that *Mus decumanus*, nowadays the common rat of Europe, either does not occur or is extremely rare in the interior of Eastern Bengal, although it is by no means rare in Calcutta and other Indian ports. Work on similar lines in other parts of India is necessary, if we are to gain an exact knowledge of the distribution of the different species, and can be undertaken by any man with a scientific training and an instinct for accuracy; but as more technical knowledge is needed for the identification of obscure forms of Muridæ, the Trustees of the Indian Museum have authorized the Superintendent while on leave in Europe to obtain the services of a competent mammalogist as temporary assistant. If the appointment of such a man can be effected, it is believed that a great deal of the confusion at present existing as regards the taxonomy of the smaller Indian mammals will be swept away, and probably the number of species said to exist will be considerably reduced.

The survey work of the Museum has been greatly facilitated by the assistance given in Nepal by the Resident, Major J. Manners Smith, V.C., C.I.E., and in the United Provinces by the Lieutenant-Governor, Sir John Hewett, K.C.I.E. The appointment of a regular collector, for which Government have given sanction during the year, has also made work very much easier, besides greatly increasing the reference collections.

Survey of the Fauna of the Indian Seas.—The zoological work of the Marine Survey of India has always been so intimately connected with the Museum that it may be considered under the same general heading. The Surgeon Naturalist on the Survey Ship "Investigator"

has for many years spent the monsoon season in Calcutta arranging and working out the collections dredged under his direction. During the present year the collections as yet received at the Museum have been smaller than usual, chiefly owing to the fact that the "Investigator" was practically put at the disposal of the zoologists appointed to investigate the Mergui pearl banks; but a complete set of the specimens obtained by these gentlemen will ultimately be deposited in the Museum. Last year's hauls, moreover, were very rich, among the most interesting specimens obtained being several of the gigantic Isopod *Bathynomus giganteus*, including an adult female with eggs, and a fine series of the bilaterally symmetrical hydroid *Branchiocerianthus*, which had not previously been obtained from Indian seas. Captain R. E. Lloyd, I.M.S., Surgeon Naturalist, who is at present attached to the Museum, is engaged on an account of the anatomy of the Isopod, and also in describing many new and interesting species of fish and crustaceans.

Year by year the zoological work of the Marine Survey of India becomes more and more important as our knowledge of the deep-sea fauna of the world increases and it, therefore, becomes possible to make a more accurate comparison between the fauna of the abysses of the Indian Ocean and that of other seas. The investigations of the Surgeon Naturalists of the "Investigator" and of those who have described their collections (especially of Lieutenant-Colonel A. W. Alcock, the retiring Superintendent of the Museum) have given Indian Zoology a unique position in the world of science. The importance, therefore, of continuing and even extending such researches cannot be overestimated, and it is to be hoped that the construction of a more modern vessel, which is to replace the old "Investigator" before this year is finished, will give increased facilities for zoological work.

Publications of the Indian Museum.—With the increase of the collections in the Museum and the increased assistance it has been found possible to obtain from foreign specialists, it has become necessary that the Museum should possess a medium for the publication of the results obtained. It has, therefore, been decided to issue a quarterly journal under the title of "Records of the Indian Museum," and to continue the issue of more extensive monographs on the Indian fauna in a serial form. Two parts of the first volume of the "Records" have already been published and two more will be issued shortly, completing the first volume.

II.—Zoological work of the Indian Colleges and Scientific Societies.

The only zoological work done during the year in any college in India, has been, with the exception of a few incidental observations on mosquitoes and parasites, an investigation into the anatomy of fresh-water *Oligochaetes* by Major J. Stephenson, I.M.S., Professor of Biology, Government College, Lahore.

The function of scientific societies is in the main to publish the results of work done in the laboratories of scientific institutions and to encourage the undertaking of such work. In India there are two societies that publish zoological papers, namely, the Asiatic Society of Bengal and the Bombay Natural History Society. The former has been the mother of almost every scientific publication in India, its latest offspring being the "Records of the Indian Museum," which must in fairness be ascribed to their proper parentage. It would be out of place in the present report to enter into a detailed account of what the Society has done for zoology in India; but the number of zoological papers recently published in its "Proceedings" and "Memoirs" is sufficient guarantee that it is not, as some have thought, purely a philological body.

The "Journal of the Bombay Natural History Society" is practically restricted to Botany and Zoology, and has shown no falling-off during the year in the number of its papers and the excellency of its illustrations. It is no reflection on the valuable work done by this Society to say that it deals mainly with the groups of animals that are most popular among amateurs and have, therefore, been most studied in the past. The appointment of a trained zoologist to be in charge of the Society's Museum (which appointment has recently been made) should, however, prove an important event in the history of zoology in western India.

III.—Medical Zoology.

The facts that militate against zoological research in the colleges are as antagonistic to the study of medical zoology. Medical men have often had special zoological training before coming to India. In India they have, with rare exceptions, no opportunity of keeping in touch with zoological literature, and no central authority to whom they can refer for advice and assistance. The staff of the Indian Museum has never chanced to include an expert on Protozoa or Diptera, and it is these two groups that have chiefly attracted students of tropical disease,

although there is every probability that others will ultimately prove important from a medical or sanitary point of view. Without a large increase in the staff of the Museum it is improbable that the services of such specialists will be available. The staff at present consists of a single officer, who is fortunate in having secured the temporary assistance of a Dipterist.

Notwithstanding the difficulties under which they labour, zoological work bearing directly or indirectly on medical studies has recently been done by several members of the Medical Service, and has been published in the "Scientific Memoirs of the Officers of the Medical and Sanitary Departments" and in the form of notes in various medical journals.

IV.—Zoological work on Fisheries.

The Government of Bengal have published a report on the fisheries of the province by Mr. K. G. Gupta, I.C.S. Beyond dealing in a general way with the distribution and habits of a few common species, the report wisely ignores the biological problems involved, for it is stated that a trained zoologist will be appointed to assist Mr. Gupta's successor, who will apparently be another member of the Indian Civil Service. Investigations on the Madras fisheries of a statistical and economic nature have been continued under a retired member of the same service, but nothing of biological interest has as yet been published. A collection of marketable fishes was made at Akyab in February last by an agent of the Reporter on Economic Products, and has been worked out in the Indian Museum by Captain Lloyd. Including "whitebait," it comprised over seventy species, of which one has proved new to science (*Lactarius burmanicus*) although apparently not uncommon, while several were of considerable zoological interest. It is hoped that it may be possible to make similar collections during next year at different fishing centres, and arrangements have already been made as regards specimens from the Chilka Lake in Orissa.

During the early part of the year, the Government of India, at the request of the Government of Burma, appointed two zoologists, Mr. Rudmose Brown, late Naturalist to the Scottish Antarctic Expedition, and Mr. Simpson, late assistant to the Professor of Zoology at Aberdeen, to investigate the pearl banks of Mergui. Their time on the Burmese coast was extremely short, and their report has not yet been published. Mr. Brown has, however, published a short general paper

in the Scottish Geographical Journal. The collection, of which a complete set will be deposited in the Indian Museum, should prove of great interest in conjunction with those made in Mergui by the late Dr. J. Anderson, which we already possess. A set of the pearl oysters (three species) collected in the Persian Gulf has been submitted for identification to the Indian Museum. Some of the shells examined are much injured by the burrows of a mussel (*Lithodomus malaccanus*), which does not appear to have been previously reported as an enemy of pearl oysters.

V.—The "Fauna of British India and Ceylon."

Three volumes on insects have recently been published in this series, two on butterflies by Lieutenant-Colonel Bingham, and one on Cerambycidæ (beetles) by Mr. Gahan. Two others are in the Press, one on the remaining families of the Homoptera by Mr. W. L. Distant and one on Phytophagous beetles by Mr. Martin Jacoby, others on insects being in various stages of progress.

VI.—Work on Indian Zoology in European and American Colleges and Museums.

The greater part of the work done abroad during the year on Indian collections has been done on specimens sent out from the Indian Museum. In the British Museum Messrs. G. A. Boulenger and Tate Regan have worked at Amphibia and fish from this source; in the Hamburg Museum Dr. Michaelsen has devoted a considerable part of his time to a large collection of Indian earthworms, while Dr. Kraepelin has examined freshwater Polyzoa; in the "Polytechnicum" of Budapest Prof. von Daday has been occupied by the collection of microscopic freshwater fauna already alluded to; in Paris Prof. Joubin is examining the "Investigator" Brachiopods and Prof. Blanchard the leeches; at Lyon Prof. Koehler has nearly completed his monograph on the shallow-water Holothurians of the Indian coasts; while at Aberdeen Prof. J. Arthur Thomson, who has recently described the deep-sea Alcyonarians, is doing the same for the shallow-water representatives of the group; in the Royal Scottish Museum at Edinburgh Mr. Ritchie has commenced work on the Museum collection of hydroids; in the University of Liverpool Miss L. Thornely has concluded a report on the marine Polyzoa; in New York State Prof.

Needham has nearly finished his description of the Neuroptera; while the Orthoptera, Curculionidæ, Lamiidæ, Cetoniidæ and Dynastidæ are being named in the British Museum, in connection with the "Fauna of British India," under the superintendence of Colonel Bingham.

List of the Chief Memoirs on Indian Zoology published in 1906-07.

In the Annals and Magazine of Natural History.

Natural History Notes from the R.I.M.S. "Investigator," Series III, No. 13.—Two new barnacles dredged in 1905-06, by N. Annandale, B.A., D.Sc. Series 7, vol. xviii, 1906, p. 44.

Ditto, No. 14.—Notes on the skull of the genus *Aulastomatomorpha*, with descriptions of some new deep-sea fish, by R. E. Lloyd, M.B., B.Sc., Captain, I.M.S. *Ibid.*, p. 306.

Ditto, No. 15.—Second preliminary report on the deep-sea Alcyonaria collected in the Indian Ocean, by Prof. J. Arthur Thomson, M.A., and W. D. Henderson, M.A., B.Sc. *Ibid.*, p. 427.

Oriental Reduviidæ, by W. L. Distant. *Ibid.*, p. 363.

On some undescribed Phytophagous and Parasitic Hymenoptera from the Oriental Zoological Region, by P. Cameron. Vol. xix, 1907, p. 166.

Diagnoses of new species of *Corbula* and *Bithinella* from Lower Bengal, by H. B. Preston, F.Z.S. *Ibid.*, p. 215.

In the Annales de la Société Entomologique de France.

Arachnides de l'Inde, Part II, par E. Simon. Vol. lxxv, 1906, p. 279.

In the Bulletin de la Société Entomologique de France.

Remarques sur les Anchonoderides de l'Inde, et descriptions d'espèces nouvelles, par Maurice Maindron. 1906, p. 75.

Deux nouveaux *Anthicus* du Kashmir, par Maurice Pic. 1906, p. 78.

In the Journal of the Asiatic Society of Bengal.

Notes on the Freshwater Fauna of India, Nos. IX-XII, by N. Annandale, B.A., D.Sc. Vol. iii, pp. 15, 27, 79 and 83, 1907

Breynia vredenburgi, an undescribed Echinoid from the Indian Ocean, by Major A. R. S. Anderson, I.M.S., B.A., C.M.Z.S. Vol. iii, No. 3, p. 145.

In the Journal of the Bombay Natural History Society.

A new Tortoise from Travancore, by G. A. Boulenger, F.R.S. Vol. xvii, No. 3, p. 560, 1907.

On the parasitic Hymenoptera collected by Major C. G. Nurse in the Bombay Presidency, by P. Cameron. *Ibid.*, p. 578, 1907.

Some new Asian snakes, by Captain F. Wall, I.M.S., C.M.Z.S. *Ibid.*, p. 612, 1907.

The Moths of India. Supplementary paper to the volumes in the "The Fauna of British India" series, III, Part III, by Sir George Hampson, Bart., F.Z.S., F.E.S. *Ibid.*, p. 645, 1907.

The Zoology of Indian Parasitic Cuckoos, Part III, by E. C. Stuart Baker, F.Z.S. *Ibid.*, p. 678, 1907.

Birds of the Provinces of Kashmir and Jammu and adjacent districts, Part III, by A. E. Ward. *Ibid.*, p. 723, 1907.

Descriptions of Indian Micro-lepidoptera, Part III, by E. Meyrick, B.A., F.R.S., F.Z.S. *Ibid.*, p. 730, 1907.

An enquiry into the parasitic habits of the Indian Koel, by D. Dewar, I.C.S., F.Z.S. *Ibid.*, p. 765, 1907.

Birds of the Khasia Hills, Part I, by E. C. Stuart Baker, F.Z.S., M.B.O.U. *Ibid.*, p. 783, 1907.

A popular treatise on the common Indian snakes, Part IV, by Major F. Wall, I.M.S., C.M.Z.S. Vol. xvii, No. 4, p. 857, 1907.

Additional cuckoo notes, by E. C. Stuart Baker, F.Z.S. *Ibid.*, p. 876, 1907.

The common butterflies of the plains of India, Part III, by L. C. H. Young, B.A., F.E.S., F.Z.S. *Ibid.*, p. 921, 1907.

Notes on small Mammals in Kashmir and adjacent districts, by Colonel A. E. Ward. *Ibid.*, p. 928, 1907.

Birds of the Provinces of Kashmir and Jammu and adjacent districts, Part IV, by Colonel A. E. Ward. *Ibid.*, p. 943, 1907.

Birds of the Khasia Hills, Part II, by E. C. Stuart Baker, F.Z.S., M.B.O.U. *Ibid.*, p. 957, 1907.

Descriptions of Indian Micro-lepidoptera, Part IV, by E. Meyrick, B.A., F.R.S., F.E.S. *Ibid.*, p. 976, 1907.

The poisonous snakes of India and how to recognize them, by Major F. Wall, I.M.S., C.M.Z.S. *Ibid.*, p. 995, 1907.

Notes on some rats of the *Mus mettada* group, by R. C. Wroughton. *Ibid.*, p. 997, 1907.

Description of a genus and some new species of Hymenoptera captured by Lieutenant-Colonel C. G. Nurse at Deesa, Matheran and Ferozepore, by P. Cameron. *Ibid.*, p. 1001, 1907.

In the Journal of the Linnæan Society.

A freshwater Isopod from Calcutta, by the Revd. T. R. R. Stebbing, M.A., F.R.S. Vol. xxx, No. 195, May 1907, p. 39.

In the Proceedings of the Zoological Society of London, November and December, 1906.

The Mollusca of the Persian Gulf, Gulf of Oman and Arabian Sea, as evidenced mainly through the collections of Mr. F. W. Townsend, 1893-1906, with descriptions of new species, by James Cosmo Melvill, M.A., F.L.S., F.Z.S., and Robert Standen; Part II, Pelecypoda, p. 783.

On the occurrence of the Bruang in the Tibetan Province, by R. Lydekker, p. 997.

On the Nudibranchs of Southern India and Ceylon, No. II, by Sir Charles Eliot, K.C.M.G., F.Z.S., p. 999.

In the Journal of the Royal Microscopical Society.

Protozoa of Mosquitoes in India, by Ronald Ross. Part 2, April 1907, p. 179.

Some Tardigrada of the Sikkim Himalaya, by James Murray. Part 3, June 1907, p. 269.

On some Rhizopods from the Sikkim Himalaya, by Eugene Penard. *Ibid.*, p. 274.

In the Memoirs of the Asiatic Society of Bengal, Vol. ii, No. 1, 1907.

Cirrhépèdes operculés de l'Indian Museum de Calcutta, par A. Gruvel.

In the Memoirs of the Indian Museum, Vol. i, No. 1, 1907.

An account of the rats of Calcutta, by W. C. Hossack, M.D.

In the Records of the Indian Museum.

Contributions to the Fauna of the Arabian Sea, by Captain R. E. Lloyd, B.Sc., I.M.S. Vol. i, part 1, 1907, p. 1.

Records of Hemiptera and Hymenoptera from the Himalayas, by C. A. Paiva. *Ibid.*, p. 13.

Further notes on Indian freshwater Entomostraca, by R. Gurney. *Ibid.*, p. 21.

The Fauna of brackish ponds at Port Canning, Lower Bengal, Parts I—III, by N. Annandale, B.A., D.Sc., and Dr. O. von Linstow. *Ibid.*, p. 35.

Revision of the Oriental Stratiomyidæ, by E. Brunetti. Vol. i, part 2, 1907, p. 85.

Description of an Oligochæte worm allied to Chætogaster, by Major J. Stephenson, I.M.S. *Ibid.*, p. 133.

The Fauna of brackish ponds at Port Canning, Lower Bengal, Part IV, by N. Annandale, B.A., D.Sc. *Ibid.*, p. 139.

Further note on a Polyzoan from the Himalayas, by N. Annandale, B.A., D.Sc. *Ibid.*, p. 145.

Reports on a collection of Batrachia, Reptiles and Fish from Nepal and the Western Himalayas, by G. A. Boulenger, F.R.S., N. Annandale, B.A., D.Sc., Major F. Wall, I.M.S., and C. Tate Regan, B.A. *Ibid.*, p. 149.

The Fauna of brackish ponds at Port Canning, Lower Bengal, Part V, by the Rev. T. R. R. Stebbing, M.A., F.R.S. *Ibid.*, p. 159.

Notes on Oriental Diptera, Nos. I and II, by C. Brunetti. *Ibid.*, p. 163.

Report on the Marine Polyzoa in the collection of the Indian Museum, by Laura R. Thornely. Vol. i, part 3, 1907, p. 179.

The Fauna of brackish ponds at Port Canning, Lower Bengal, Part VI, by N. Annandale, B.A., D.Sc. *Ibid.*, p. 197.

A third note on Earwigs (Dermaptera) in the Indian Museum, with the description of a new species, by Malcolm Burr, B.A., F.Z.S. *Ibid.*, p. 207.

Notes on Oriental Diptera, No. III, E. Brunetti. *Ibid.*, p. 211.

Notes on a collection of marketable fish from Akyab, with a description of a new species of *Lactarius*, by Captain R. E. Lloyd, B.Sc., I.M.S. *Ibid.*, p. 219.

Description of two freshwater Oligochæte worms from the Punjab, by Major J. Stephenson, I.M.S. *Ibid.*, p. 233.

Notes on phosphorescence in marine animals, by Captain R. E. Lloyd, B.Sc., I.M.S. *Ibid.*, p. 257.

Notes on the rats of Dacca, Eastern Bengal, by Captain C. A. Gourlay, I.M.S. *Ibid.*, p. 263.

Notes on freshwater sponges, Nos. I—V, by N. Annandale, B.A., D.Sc. *Ibid.*, p. 267.

In the Annales de la Soc. Entomologique de Belgique.

Malacodermes du sud de l'Inde. Par J. Bourgeois.

Scientific Memoirs by officers of the Medical and Sanitary Departments of the Government of India, New Series, 1907.

No. 25.—On the importance of larval characters in the classification of Mosquitoes, by Captain S. R. Christophers, M.B., I.M.S.

No. 26.—*Leucocytozoon canis*, by Captain S. R. Christophers, M.B., I.M.S.

No. 27.—Preliminary report of the development of the Leishman-Donovan body in the bed bug, by Captain W. S. Patton, M.B., I.M.S.

No. 28.—The sexual cycle of *Leucocytozoon canis* in the tick, by Captain S. R. Christophers, M.B., I.M.S.

Report to the Government of Ceylon.

Report on the Pearl Oyster Fisheries of the Gulf of Manaar and Marine Biology of Ceylon, Part V, by W. A. Herdman, D. Sc., F.R.S., P.L.S., 1906.

Occasional Publication of the Indian Museum.

The Deep-Sea Alcyonarians from the Indian Ocean, by J. Arthur Thomson, M.A., B.Sc., 1906.

Aids to the identification of rats connected with plague in India, by W. C. Hossack, M.D.

Besides the papers mentioned in the above list many shorter notes, descriptions of single species, etc., have been published in the Proceedings of the Asiatic Society of Bengal, the Journal of the Bombay Natural History Society and the Records of the Indian Museum.

AGRICULTURAL ENTOMOLOGY

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

The study of the insect pests of crops was continued by the Imperial Entomologist, his staff and the Assistants in Provincial Agricultural Departments. The detailed study of the more important insect 'pests was continued in the insectary, and on the experimental farm at Pusa as well as in the field, and coloured plates representing these insects in all stages were prepared. The success attending the re-introduction of the cotton bollworm-parasite to the Punjab led to the adoption of this measure in Sind. The occurrence of swarms of locusts in the Punjab necessitated a campaign against this pest, carried on by the Punjab Agricultural Department with assistance from the Imperial Entomologist's staff. The measures adopted were those previously in use, experiment having shown that other suggested measures were less efficient, and, since the so-called Locust Fungus has been proved ineffectual, it is believed that these measures are the most satisfactory ; further experiment will not be continued.

The extension of the jute experimental plots to new tracts has necessitated special attention being paid to the pests of this crop, especially on small experimental areas, but these pests will probably be of slight importance in localities where any considerable area of jute is planted.

Greater attention is being paid to the insects injurious to indigo in Behar, the introduction of the Java-Natal plant and the consequent modification of methods of cultivation having altered the conditions and brought new pests into prominence.

The prevalence of the introduced potato moth in Bombay and of the very important Groundnut Leaf Miner in Madras have been enquired into. Insect pests of cane, and of castor, as well as termites, have also been specially investigated.

A considerable advance has been made in the work of Provincial Assistants, notably in Madras where the common pests of staple crops are being for the first time systematically investigated.

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The publication of "Indian Insect Pests" has drawn general attention to the injuries caused by insects and, judging from the inquiries received, has had a distinct effect in bringing home to the more educated agricultural community the salient facts regarding the lives of insects. This is the real benefit derived from the publication of this work. The publication of articles in the Agricultural Journal, with good coloured illustrations, has also had its effect. The increased number of enquiries received has made it possible to diffuse information more widely, and the work of Provincial Assistants is also making itself felt.

The enquiry into insecticides non-poisonous to cattle was continued and reached the stage of field trial. The experimental cultivation of the eri silk worm (*Attacus ricini*) was taken up at Pusa to determine primarily whether by any simple means the worms can be made to thrive during the hot weather. An excellent quality of silk was obtained and this work will be continued on a small scale until the problem is settled. The cultivation of lac on bair trees (*Zizyphus jujuba*) was also commenced at Pusa, partly as an educative object-lesson for students, partly to determine how far the very small existing cultivation of lac in Behar can be improved. A small experimental cultivation will be maintained, existing methods will be improved if possible and a tentative extension of lac outside Pusa is being made. The increase in the routine work, and especially in the number of enquiries received from all parts of India, has made it necessary to temporarily put aside some researches mentioned in last year's report.

Mr. C. B. Antram, Entomologist to the Indian Tea Association, has continued his work on insects injurious to tea. Further study was made of the Looper Caterpillar (*Biston suppressaria*), and Sandwich Caterpillar (*Agriophora rhombota*, Meyr.). An account of the four "Bark-eating Borers of Tea" was prepared, dealing with insects whose life histories were previously unknown. Further attention is being paid to Mosquito Blight and to mound-building White Ants.

Progress was made in the enquiry into biting flies, mentioned in last year's report. A number of biting flies was found and studied; the dreaded Tse-Tse fly of Africa was not found and this confirms the view that it does not occur in India. The collections made are

being worked out and this work will now pass into the hands of the Second Imperial Entomologist, Mr. F. M. Howlett.

Progress has been made with the Insect Survey of India carried on in co-operation with the Indian Museum, Calcutta. Further collections were sent to specialists in connection with the Fauna of India volumes and some were received back. The whole named collection is maintained in a properly arranged condition and so catalogued on cards that any group or species can be readily found.

The text of a volume on the Insects of India, with reference to the plains or cultivated areas only, was prepared as well as the necessary illustrations ; it is proposed to publish this in due course.

List of Publications.

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| MAXWELL-LEFROY, H. | . Insect Pests of Jute, Agri. Journ. of India, Vol. II, No. 1. |
| MAXWELL-LEFROY, H. | . Surface Caterpillars, Agri. Journ. of India, Vol. II, No. 2. |
| MAXWELL-LEFROY, H. | . Locusts in India, Agri. Journ. of India, Vol. II, No. 3. |
| MAXWELL-LEFROY, H. | . Practical Remedies for Insect Pests, Agri. Journ. of India, Vol. II, No. 4. |
| MAXWELL-LEFROY, H. | . The Biting Flies of India, Occasional Bull. No. 7 of 1907. |
| WARBURTON, C. | . The Ticks infesting Domesticated Animals in India, Occasional Bull. No. 6 of 1907. |
| RENOUF, W. | . Note on the Cotton failure on account of bollworm in the Central and South-west Punjab in 1905, and on the results of the measures taken to prevent a recurrence in 1906, Dept. of Agri., Punjab, Bull. No. 1 of 1907. |
| MAXWELL-LEFROY, H. | . The more important Insects injurious to Indian Agriculture, Memoirs of Agri. Dept. in India, Entomo. Series, Vol. I, No. 2. |

- MAXWELL-LEFROY, H., AND C. C. GHOSH. Indian Surface Caterpillars of the Genus *Agrotis*, Memoirs of Agri. Dept. in India, Entomo. Series, Vol. I, No. 3.
- MANN, H. H. . . . Individual and Seasonal variations in *Helopeltis theivora*, Waterhouse, with description of a new species of *Helopeltis*, Memoirs of Agri. Dept. in India, Entomo. Series, Vol. I, No. 4.
- GREEN, E. E., AND MANN, H. H. The *Coccidæ* attacking the Tea plant in India and Ceylon, Memoirs of Agri. Dept. in India, Entomo. Series, Vol. I, No. 5.
- ANTRAM, C. B. . . . A pamphlet on the "Bark-eating Borers of Tea," Indian Tea Assoc. Scientific Series, 1907 (in the Press).
- MAXWELL-LEFROY, H. . Insects injurious to books and papers.

FOREST ENTOMOLOGY

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.,
Imperial Forest Zoologist.

General.

The most important investigations of the year in Forest Entomology, both economically and scientifically, resulted from a visit paid by the Imperial Forest Zoologist to the Assam Sal Forests from March to May. One of the chief objects of the visit was a study of the defoliators of the sal belt of this region and some important additions to the life histories of these pests were made, although the season was unfavourable for the prosecution of this study. The investigations already carried out into the bark and wood-borers infesting the sal belt of the Terai and Siwalik areas of the United Provinces and into those of the Central Provinces and Chota Nagpur tracts in which this tree flourishes led to the conclusion that it was probable that the

Assam Sal Forests would be found to contain pests similar to the *Hoplocerambyx spinicornis*, or Singhbhum longicorn borer, which commits such havoc in the Central Provinces and Chota Nagpur sal areas, and to the scolytid bark-borer *Sphærotrypes Siwalikensis*, Steb., of the Siwalik and neighbouring Terai sal areas of the United Provinces and the investigations in the Goalpara Sal Forests were rich in results of a high economic importance. *Hoplocerambyx spinicornis* proves to be a most serious pest in the Assam Sal belt where it is accompanied by a species of *Sphærotrypes* which, whilst differing specifically from its confrère of the United Provinces, has very similar habits.

In addition to these two, some forty-five pests of the sal including some insects predaceous and parasitic upon these pests were studied, the life histories of some being ascertained, from a practical working point of view, in a sufficiently complete manner. Insects infesting and ruining the seed, and thus retarding or stopping the regeneration of the species, were also studied.

In the autumn of the year a tour was made in the Jaunsar and neighbouring Tehri-Garhwal areas of the United Provinces, the principal object in view being the study of pests infesting the *Pinus longifolia* forests. A serious infestation by a weevil, specimens of which were forwarded during the year by Mr. Milward from the Almora Chir (*P. longifolia*) Areas, appeared to require immediate enquiry and this was carried out in conjunction with others connected with bark and wood-boring pests of this conifer. Enquiries were also prosecuted in connection with the presence or otherwise of autumn generations of the scolytid pests infesting the Deodar, Silver fir, Spruce and Blue pine.

The Chief Economic Results of the Year.

(a) By the Imperial Forest Zoologist.

The Assam Sal Pests.—

Hoplocerambyx spinicornis (the Singhbhum Sal borer):—

The discovery that this longicorn beetle, previously well-known as a pest in the sal belt of the Central Provinces and Chota Nagpur, forms perhaps one of the most dangerous insect enemies in the sal belt of Eastern Bengal and Assam is of serious importance. With the

help of Mr. Perrée and one of his Range officers, Ram Nath Mukerjee, the life history of this insect in Assam, which varies in important particulars from that in Bengal, was worked out in such detail as to make it possible to indicate certain steps which it will be necessary to follow to prevent the insect acquiring a mastery over the sal areas.

Sphærotryps assamensis n. sp.—This bark-feeding Scolytid pest is by itself capable of killing living sal trees when present in sufficient numbers. As it would appear to pass through five generations in the year its appearance in an area must always be looked upon as a possible serious danger to the forest. When present in company with *H. Spinicornis*, as is the case in the Goalpara sal areas, the damage these two pests are able single handed to commit is gravely aggravated.

Other Assam Sal Pests.—Other species of longicorn beetles infesting the sal studied were *Dialages pauper*, *Caloclytus sp. prox. signaticollis*, *Thysia Wallichii* and *Cerambyx sp.* Amongst Scolytidæ bark and wood-borers may be mentioned species of *Phlæosinus*, *Dolurgus*, *Dryocetes*, *Tomicus*, *Acanthotomicus*, *Xyleborus*, *Platypus* and *Diapus*. Important observations were also made on the life histories of the defoliators *Clania variegata*, *Suana sp.* and species of *Dasychira* and *Lymantria*.

The Sal Seed destroyers.—The larvæ of three minute moths, species of *Conogethes*, *Laspeyresia* and *Cacæcia* and the grubs of a twig Scolytid beetle, probably a species of *Xyleborus*, feed inside the sal seed, entirely hollowing out the embryo and thus destroying the natural reproduction of the forest. Sixty to seventy per cent. of the sal seed examined in the Kochugaon Forests of the Goalpara Division in May 1906 was found to be infested by the grubs of these pests.

Predaceous and Parasitic Insects.—Notes on some important species of *Ichneumon*, *Chalcis*, *Bothridæ*, *Niponius*, *Thanasimus* and *Platysoma*, insects parasitic and predaceous upon the Assam Sal pests, were also recorded.

Charduar Rubber Plantation Pests.—A visit was paid to this plantation which is situated in the Darrang Division in Assam, in March 1906, during which some observations were recorded on the life history of the rubber defoliating pest *Gunda sikkima* and notes recorded on a number of other pests of the *F. elastica*.

Pinus Longifolia Pests.

Cryptorrhynchus sp.—At the beginning of September Mr. R. C. Milward forwarded some dying *P. longifolia* saplings from a plantation in Almora. These were found to be infested by a species of Cryptorrhynchid weevil, the bast layer of the trees being riddled by the grubs of the beetle. Investigations carried out in Jaunsar and Tehri-Garhwal in October and November of the same year showed that this pest attacks large full grown trees as well as saplings, and that it infests green standing trees.

Tomicus and Polygraphus Bark-borers.—It was a point of considerable interest to find that *Pinus longifolia* is attacked by species of *Tomicus* and *Polygraphus* bark-borers entirely different from those infesting the *P. excelsa* and Spruce, trees living at a higher elevation in the conifer zone than *P. longifolia*. Both these important pests require considerable further study.

The Scolytid wood-borers.—Forest Officers and Tea Planters have often complained that the wood of this tree is perforated by 'shot-borers' which have been considered to be identical with the 'ghoon' or 'shot-borers' of the bamboo. Investigations into this attack has brought to light some remarkable facts and have proved that the originator of the holes is a species of *Platypus* (Fam. *Scolytidæ* or *Platypodæ*) totally distinct from the bamboo shot-borers. This insect drills holes down into the timber to lay its eggs, and attacks freshly felled trees and standing green or sickly trees.

Other Himalayan Coniferous Pests.—Considerable progress was made in the investigations into the autumn life histories of Scolytid pests of the deodar, spruce, silver fir and blue pine, but the observations carried out still necessitate further work on the life histories to enable practical means of combating the attacks and of preventing an increase in the numbers of these pests in the valuable Himalayan Forests.

The Chermes abietis-piceæ of the Spruce and Silver fir.—It is believed that the search instituted for the winter egg and stem female of this important and interesting insect has been successful.

The Sphærotypes bark-borer in the Siwalik and neighbouring Terai Sal areas.—This insect was alluded to in the last report. It is still considered that the presence of this pest in unusual numbers in this sal areas is a source of considerable danger to the forests owing

to the sickly state of numbers of the trees, a legacy of the severe frosts of February 1905.

(b) *By Other Departmental Observers.*

Studies on the Assam Sal Pests.—During the visit of the Imperial Forest Zoologist to Goalpara and after his departure independent personal investigations were carried on in the life histories of Goalpara Sal Pests by the Divisional Officer, Mr. W. F. Perrée, and Extra-Assistant Conservator Ram Nath Mukerjee. The very considerable progress these investigations have reached must be in large measure attributed to the great assistance freely afforded by these officers.

The Cryptorrhynchus weevil in the Almora Pinus Longifolia area:—The discovery of this insect by Mr. R. C. Milward, Deputy Conservator of Forests, Naini Tal Division, and Ranger B. D. Kalia in the Kalimat Plantation near Almora has already been alluded to. The observations made by these officers are of valued importance.

Lymantria semicincta in the Balaghat Sal Forests.—Mr. A. St. V. Beechey made some interesting observations on the life history of a sal-defoliating caterpillar which was subsequently identified as *Lymantria semicincta*. The defoliation took place in April. The attack in question was apparently greatly reduced by a parasitic Tachinid fly resembling a species of *Mascicera*.

Albizzia Lebbek Seed attacked by Caryoborus sp.—The Divisional Officer, Nasik, Bombay Presidency, reported that *Albizzia Lebbek* seed in his division was infested by a beetle which was identified as *Caryoborus* sp. previously reported from Bombay in this connection.

Injurious Pests in the North Coimbatore Division, Madras.—Mr. C. E. C. Fischer reported that considerable defoliation was done to *Anogeissus latifolia* in May-June about Bailur and Gairmalam, 4,000' to 4,300', in many places groups of trees being entirely leafless. Mr. T. N. Hearsey reported similar attacks near Lokanhalli, 2,600', in April 1905. The defoliation was done by caterpillars of species of *Pheosia*, *P. fasciata*, *P. strigata* and *P. sikkima*. *P. strigata* only had been previously reported from the Madras Presidency.

The caterpillars of the common moth pest *Ophnisa melicerta* were also reported as defoliating this tree at Bailur.

Arbela tetraonis and Clania Crameri in Casuarina plantations at Nellore.—The bark-eating caterpillar of the moth *Arbela tetraonis* and the bag worm *Clania Crameri* were again reported as committing depredations in the Casuarina plantation of Nellore.

Acanthophorus serraticornis in Mango in Ganjam.—Some important observations on the life history of a longicorn-borer, identified as *Acanthophorus serraticornis*, infesting the mango in Ganjam, Madras, were carried out by Mr. S. Cox, Divisional Forest Officer, Ganjam, and Mr. H. T. Reilly, I.C.S., Head Assistant Collector, Chicacole, Ganjam. This insect is one of the largest known of Indian Cerambycidae, and the discovery is made for the first time that its grubs, which have previously been reported as infesting sal wood, riddle mango trees. Serious injury is done by the insect to valuable mango orchards in this locality.

The Teak defoliators in Travancore.—The Conservator of Forests, Travancore, continued to forward to this office during the year quarterly reports detailing the areas and percentage of teak forest attacked by the teak defoliators *Hyblaea pueria* and *Pyrausta damastesalis*. These reports have now been sent in for several years, and some interesting and valuable information on the subject of the periodicity and severity of the attacks of these pests will shortly be available for publication.

The teredo marine-borer in Bamboos.—Experiments were commenced during the year to test whether bamboos placed in sea and tidal waters are subject to the attacks of the teredo borer and if so in how short a period after exposure they will be tunnelled into. The experiments which were made after the close of the year with various species of bamboo have shown that whilst all species ultimately succumb to the teredo their powers of resistance vary.

Bostrichidae infesting Engyin wood in Rangoon Depôts:—Mr. F. Wood of Messrs. Foucar & Co., of Rangoon, forwarded through Mr. S. Carr, Deputy Conservator of Forests, a beetle identified as a species of *Bostrychopsis* which was discovered tunnelling into Engyin (*Pentacme suavis*) logs in the firm's depôt. As the beetles of this family prove at times serious timber pests, the firm in question has been asked for a further report on the subject.

By other Observers.

Help afforded by authorities in combating the Quetta-borer.—

The 'Quetta Borer' attack, as it is known, was fully dealt with in last year's report. A part of the treatment advocated for getting rid of the pest was to leave standing a certain number of affected 'trap' trees throughout the station, at the time the heavy fellings were being made, with the object of affording the beetles, issuing in the spring subsequent to the fellings, localities for egg-laying and thus preventing their attacking as yet unaffected healthy trees. The suggested treatment laid down, that these trap trees were to be felled and burnt in the following autumn, was undertaken and this part of the work was successfully brought to a close by the authorities. It is hoped that these operations will have reduced the numbers of the beetle to normal and thus prevent further damage being done to the avenues in the station.

The Duki Fig-tree Borer (*Batocera Rubus*).—Major C. A. Kemball, C.I.E., Political Agent, Loralai, reported that the fig trees in the Duki garden in his agency were being attacked and killed by a borer resembling the Quetta borer. As the fig tree is planted in many of the fruit gardens in Baluchistan it was of considerable importance, in view of the operations being undertaken in Quetta, to identify this pest as early as possible. Under instructions sent to him Major Kemball, some months later, was able to forward perfect specimens of the beetle whose grubs were committing the damage. It proved to be *Batocera rubus* and thus set the fears aroused as to its identity with the Quetta borer to rest. In a note issued during the year the necessary treatment to be put in force was indicated and through the Honourable the Agent, all officers in Baluchistan were instructed to keep a watch for this pest.

Buprestid grubs in Poplar and Willow trees in Loralai, Baluchistan.—A communication was forwarded by Colonel G. F. Goot, Commanding 37th Cavalry, Loralai, to the effect that the poplars and willows in the station were being tunnelled into by grubs similar to the Quetta borer. As the latter insect has not yet been found in Loralai this communication was of interest. The specimens of grubs sent proved, however, to be *Buprestidæ*. No beetle has yet been taken.

Chief Scientific Results of the year.

The distribution of *Hoplocerambyx spinicornis* and *Sphærotrypes* in the Indian Sal belt.—Although the longicorn *H. spinicornis* had been previously reported from Assam, the discovery that it was a serious pest in the sal forests of Eastern India and the observations made on its life history are recorded for the first time in 'Some Assam Sal Insects,' a monograph compiled during the year. *Sphærotrypes* has not yet been taken in the sal areas in the Central Provinces, Chota Nagpur and Ganjam, but the genus is now known in the sal belts of the United Provinces, Siwaliks and Terai and in Buxa Duars, Bhutan and Assam and it is probably the most dangerous bast-eating Scolytid of these areas.

***Pinus longifolia* bark and wood-borers.**—The discovery of species of *Tomicus* and *Polygraphus*, bast-eating beetles, different from those infesting the *P. excelsa*, in the *Pinus longifolia* is of considerable interest in that it proves that the Himalayan conifers are probably subject to attack by a greater number of distinct species of Scolytid beetles than are their European confrères. It is also of importance to determine the chief wood-borers of this tree and it is significant, as proving the Indian economic importance of the family which is but sparsely represented and of little economic importance in Europe, that one of them should prove to be a species of *Platypus* (Fam. *Platypodæ*).

Literary Work.—Amongst purely literary work may be mentioned the 'Note on the Duki Fig-tree borer (*Batocera rubus*)'; a monograph on 'Some Assam Sal Insect Pests' containing a large amount of original investigation work including descriptions of new *Scolytidæ*; a monograph on the Lac Insect; and the series entitled 'Insect Life in India and how to study it' published in the Journal of the Bombay Natural History Society.

Co-operation of Experts.—I have to acknowledge the usual hearty co-operation of the experts at the British Museum, Paris and Berlin Museums, and my other scientific confrères working at particular branches of natural history.

List of Publications.

- STEBBING, E. P. . . . A note on the Duki Fig-tree borer of Baluchistan (*Batocera rubus*). Forest Bulletin No. 10 (1907).

- STEBBING, E. P. . . . The Phases of the moon on the period for felling bamboos—Indian Forester, xxxii, 534.
- STEBBING, E. P. . . . On Some Assam Sal (*Shorea robusta*) Insect Pests—Forest Bulletin No. 11 (not yet issued).
- DESNEUX, J. . . . The Kashmir Termite (*Termes Wroughtoni*)—Journal, Bombay Natural History Society, xvii, 293.
- STEBBING, E. P. . . . On the life history of *Termes (Coptotermes) Gestroi*, the Hevea rubber Termite—Indian Forester, xxxiii, 6.
- STEBBING, E. P. . . . *Lecanium capreae*, Linn, as a pest of Almond trees in Baluchistan—Indian Forester, xxxiii, 168.
- STEBBING, E. P. . . . *Icerna Aegyptiaca*, Dougl. on teak in Burma—Indian Forester, xxxiii, 222.
- STEBBING, E. P. . . . Insect Life in India and how to study it—Journal, Bombay Natural History Society, xvii, 424.
- STEBBING, E. P. . . . A Note on the Lac Insect (*Tachardia lacca*)—Indian Forest Records, i., Part i, p. 1 (not yet issued).
- STEBBING, E. P. . . . Departmental Notes on Insects that affect Forestry, Vol. ii.

VETERINARY SCIENCE

BY

COLONEL H. T. PEASE, C.I.E., I C.V.D.,

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Sero-therapy.

1. As during the last year, considerable progress was made within the official year 1906-07 at the Muktesar Laboratory. The output of different sera and other prophylactics was greatly increased. This has occupied most of the time of the staff.

2. The following table will show the material difference between the preparation and issue of different products during the past year, as compared with the previous one :—

NAME OF SERUM.	Quantity prepared.	Quantity issued.	Increased manufacture as compared with last year.	REMARKS.
	Doses.	Doses.	Doses.	
Anti-Rinderpest	467,993	458,661	256,586	
Anti-Anthrax	15,280	11,814	Nil.*	* Demand for this serum decreased.
Hæmorrhagic Septicæmia	88,875†	57,375	73,405	† For trial in the field.
Charbon Symptomatique	17,869	930	17,869	
Mallein	11,276	3,583	7,869	
Tetanus Antitoxin	22,164‡ C. C.	...	22,164 C. C.	‡ Not yet tested.

According to the statistics received in this office from the Superintendents of the Civil Veterinary Departments in India and Burma, the following table, showing numbers of outbreaks dealt with and animals injected, etc., during the past 12 months, has been compiled :—

NAME OF DISEASE.	Number of outbreaks dealt with.	Number of animals injected.
Rinderpest	1,313	197,259
Anthrax	137	12,668
Hæmorrhagic Septicæmia	187	36,105

Training of Officers and Veterinary Assistants.—During the months of June to September 1906 inclusive, two officers of the Civil Veterinary Department and three of Army Veterinary Corps attended the theoretical and practical classes, each one lasting for 2 months; in

addition 49 Veterinary Assistants were trained throughout the year in different methods of inoculation and serum therapeutics.

Examination of Specimens.—Reports were made on 80 specimens submitted to the Laboratory for microscopical examination from different parts of India and Burma, with the least possible delay to the respective officers interested in the same.

Extension of the Laboratory.—It is a satisfaction to note that up to the time of writing this report, great additions have been recently made to the buildings and machinery of the Imperial Bacteriological Laboratory at Muktesar, with a view to meet the ever-increasing demand of the different products prepared at this Laboratory and also to isolate the different sheds and to minimize, as far as possible, any chance of infection or contamination of the products prepared.

For this reason separate small laboratories fully equipped with apparatus, etc., self-maintained and independent of each other, together with the necessary stables or sheds at a distance apart, have been erected for the preparation of Tetanus anti-toxin, Mallein, Charbon Symptomatique vaccines, etc.

The following work done has been recorded in the Journal of Tropical Veterinary Science or in the Annual Report:—

Dourine.—Further notes bearing on the *Trypanosoma equiperdum* with special reference to its presence in the plaques, measurements under various conditions and the immunity, if any, it confers against the *Tr. evansi* were published in the Journal of Tropical Veterinary Science, Vol. I, No. 4, p. 333.

No further experiments could be initiated in the Laboratory as the disease died out there, the horses under observation having all apparently recovered. Some investigations were made at the Punjab Laboratory into a disease simulating Dourine and caused by a filaria, a note on which was published in Vol. I, No. 4, p. 414 of the Journal of Tropical Veterinary Science.

Spirochætosis in plains and hill cattle and in fowls.—This form of disease, not previously recognised in this country, was met with during the year in cattle suffering from Rinderpest, and an account of it was published under the title of "Some forms of spirochætosis met with in animals in India" in the July number of the Journal of Tropical Veterinary Science.

Spirillosis of fowls was found to be widespread and cause considerable losses in the Punjab, the transmitting agent being *Argas persicus*.

Piroplasmosis and Trypanosomiasis.—As opportunities offered, advantage was taken of material available in the laboratories to further investigation in regard to Piroplasmosis and Trypanosomiasis in cattle, horses, camels and dogs.

A detailed report on the different species of Trypanosomata observed in Bovines in India was published in Vol. II, No. 1 of the Journal of Tropical Veterinary Science.

A note on equine biliary fever was also published in the same Journal.

Canine piroplasmosis was found to be a common affection in the Punjab, but no observations have so far been published.

With regard to Trypanosomiasis observations of the course of the disease in various animals, treatment by means of drugs, notably atoxyl, and the identity or otherwise of the Trypanosomes causing equine and cameline Surra, have been carried out. The results of treatment are not, so far, constant, and work is being continued in this direction.

It has been found that the Indian elephant was either insusceptible or only very slightly susceptible to equine Surra.

Irritable summer skin disease.—Some preliminary work has been done in this troublesome skin disease, and attention drawn to its probable parasitic nature. A note was published on the subject in the Journal of Tropical Veterinary Science, Vol. II, No. 2.

Rinderpest. It has been found that, in some cases at least, the Indian elephant is apparently not susceptible to Rinderpest.

Hæmorrhagic septicæmia.—Some further work on immunity against this disease was carried out.

A list of publications contributed during 1906-07 from the Imperial Bacteriological Laboratory.

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|-------------|---|---|---------------------------------------------------------------------------------------------------------------------------------|
| LINGARD, A. | . | . | Annual Report of the Imperial Bacteriological Laboratory for 1906-07. |
| LINGARD, A. | . | . | Further Notes bearing on the <i>T. Equiperdum</i> with special reference to its presence in plaques, measurements under various |

- conditions and immunity conferred, if any, against the *T. Evansi*. Journal of Veterinary Science, Vol. I, No. 4, p. 333.
- LINGARD, A. . . . Different species of Trypanosomata observed in Bovines in India. Journal of Veterinary Science, Vol. II, No. 1, p. 4.
- LINGARD, A., AND P. A Note on a new species of Trypanosoma discovered in the blood of an Indian bullock at Singapore. Journal of Veterinary Science, Vol. II, No. 2, p. 217.
- LINGARD, A. . . . Some forms of Spirochetosis met with in India. Journal of Veterinary Science, Vol. II, No. 3.
- LINGARD, A. . . .

A list of papers published during 1906-07 bearing on such diseases.

- BALDREY, F. S. H. . . Some problems in sheep diseases. Journal of Veterinary Science, Vol. I, No. 4, p. 387.
- BALDREY, AND W. A. A Preliminary Note on Neutral reaction in the Infected Red Cells of Protozoal diseases. Journal of Veterinary Science, Vol. II, No. 4, p. 169.
- BURTON CLELAND, J. . . Nodules containing Larval Nematode worms in the Intestinal Submucosa of a bullock. Journal of Veterinary Science, Vol. II, No. 1, p. 67.
- JOLIFFE, C. H. H. . . Some remarks on Equine Biliary Fever in India. Journal of Veterinary Science, Vol. II, No. 1, p. 51.
- MESNIL, F., AND Treatment of Trypanosomiasis with Benzidine colors. Journal of Veterinary Science, Vol. II, No. 1, p. 101.
- NICOLLE, M.
- MESNIL, F., AND Sensibility of Ruminants and Monkeys to the Trypanosoma of Dourine. Journal of Veterinary Science, Vol. II, No. 2, p. 177.
- ROUGET, I.
- NESFIELD, V. B. . . Preliminary Note on a Parasite found in connection with "The Irritable Summer skin

- disease" of horses in India. *Journal of Veterinary Science*, Vol. II, No. 2, p. 172.
- PRICOLO ANTONIO . Further contribution to the study of Equine Piroplasmosis. *Journal of Veterinary Science*, Vol. II, No. 1, p. 122.
- PEASE, H. T. . A disease simulating Dourine caused by *Filaria*. *Journal of Veterinary Science*, Vol. I, No. 4, p. 414.
- PLACE, F. EVELYN . Intra-ocular Infection by Tetanus. *Journal of Veterinary Science*, Vol. I, No. 4, p. 417.
- PATE, CHAS. W. . Rabies in a goat. *Journal of Veterinary Science*, Vol. I, No. 4, p. 419.
- RODET, A., AND VALLET, G. Contribution to the study of Trypanosomiasis—Experiments with *Trypanosoma Brucei*. *Journal of Veterinary Science*, Vol. II, No. 2, p. 184.
- STOCKMAN STEWART . Anthrax. *Journal of Veterinary Science*, Vol. I, No. 4, p. 432.
- THEILER . . Transmission and inoculability of Spirillosis in cattle. *Journal of Veterinary Science*, Vol. I, No. 4, p. 421.
- TUCK, GNOH LEAN . Observations on some worms formed in the Aortas of buffaloes and bullocks. *Journal of Veterinary Science*, Vol. I, No. 1, p. 69.
- WALKER, G. K. . A Preliminary Note on "Gillar," a disease affecting sheep and goats. *Journal of Veterinary Science*, Vol. I, No. 4, p. 410.

PROGRAMMES OF WORK FOR 1907-08.

PROGRAMMES OF WORK OF THE VARIOUS SCIENTIFIC DEPARTMENTS FOR THE YEAR 1907-08, AS APPROVED BY THE BOARD ON THE 20TH DECEMBER 1907.

1. The Imperial Institute, London, and the Department of Economic Products, Calcutta.

1. Samples of Indian Turpentine will be reported on by the Director of the Imperial Institute.
2. Investigations of myrrh, frankincense, byssabol, habaghadi and allied products are being prosecuted.
3. Ngai Camphor from *Blumea balsamifera* is under study.
4. The fats of the seeds of various nutmegs are being studied by the Curator, Industrial Section, Indian Museum.
5. The dye stuffs, *Hibiscus sabdariffa*, *Onosma echiioides*, *Thespesia populnea* and *Baccaurea sapida*, are still under study at Leeds and the Imperial Institute.
6. Investigations on the tanning barks of *Shorea robusta* and *Terminalia tomentosa* will be carried on by the Director of the Imperial Institute.
7. A preliminary report on the races of jute will be issued conjointly with Mr. R. S. Finlow, Fibre Expert to the Government of Eastern Bengal and Assam.
8. Pharmacological investigations will be continued on the Aconites by the Director of the Imperial Institute and Professor Cash.
9. The study of the following indigenous Indian drugs, by physicians in India, will be continued :—*Adhatoda vasica*, *Alstonia scholaris*, *Cæsalpinia bonducella*, *Calotropis procera*, *Embelia ribes*, *Ipomœa hederacea*, *Picrorhiza kurrooa*, *Podophyllum emodi*.
10. The collecting of information of the gentianaceous bitters of India will be prosecuted.
11. Chemical analyses are in progress at the Imperial institute of *Hyoscyamus niger*, *H. reticulatus*, *Datura stramonium* and *Datura fastuosa*, sufficient material having been supplied from India. The idea underlying the investigation is the possibility of sending supplies of these from India to the European drug market.

12. Material sent to the Imperial Institute for investigations on Strychnos beans, etc., will be examined there.

13. A report on the races of Juar (*Anaropogon sorghum*) in India will be drawn up during the year by the Reporter on Economic Products.

14. Rice grain will be subjected to chemical examination by the Curator, Indian Museum, Industrial Section, with special reference to its uses as a material for making sizes, and to its nutritive value.

15. A report on the Yams (*Dioscorea* spp.) of India will be drawn up during the year by the late Director of the Botanical Survey and the Reporter on Economic Products.

16. The origin of reeds of native pens will be reported on.

17. Pottery clays by arrangement with the Director of the Geological Survey have been collected by the Reporter on Economic Products and will be examined chemically by Professor Dunstan.

18. Completion of an investigation on opium alkaloids, including an improvement of the method of extracting morphine and codeine from waste opium. (Imperial Institute.)

19. Further examinations of the tanning properties of *Cæsalpinia digyna* pods, arranged in conjunction with the Forest Department. (Imperial Institute.)

20. Suggested examination of red and white Rangoon beans in order to see what amount of prussic-acid-forming glucoside they contain. (Imperial Institute.)

21. Suggested examination of sources of oil, in which connection the Director of the Imperial Institute remarks : " At present there is great scarcity of oilseeds in the United Kingdom, and these materials are selling at high prices. It would be well, therefore, to send to the Imperial Institute for examination any little known oilseeds which are likely to be obtainable in commercial quantities either as forest products or by cultivation. In this connection, it may be mentioned that owing to the introduction of methods depending on the use of solvents for the extraction of oils, it is now possible to use commercially many materials of this class which were formerly unsaleable as oil-yielding products, such as Soy beans and oil-cakes prepared by native methods and containing eight per cent. of oil or more."

22. Examination of supposed pitch-blende at the request of the Director of the Geological Survey. (Imperial Institute.)

2. Meteorological Department.

Astronomy.—The strengthening of the staff at Kodaikanal through the arrival of the Assistant Director will enable the routine work to be extended. It is proposed to include—

- (a) photographing of the sun in monochromatic light by means of the spectroheliograph fed by a twelve-inch lens of twenty feet focal length ;
- (b) photographing spot-spectra made with a plane or a parabolic grating fed by a six-inch lens of forty feet focal length ;
- (c) spectroscopic visual observations of sunspots and prominences by means of an Evershed spectroscope on a six-inch equatorial ;
- (d) photographing the sun in ordinary light with a photoheliograph.

The programme arranged with the International Solar Union, co-operation with which had previously been decided upon, will probably involve the detailed examination of the portion of the spectrum from b towards F .

Meteorology.—*Study of the conditions determining the amount of Monsoon Rainfall and Cold Weather Precipitation.*—As already stated in the report for 1906-07, the area over which the weather appears to be connected with that of India, is considerably larger than had formerly been supposed, and it is proposed to investigate further the relationships between the meteorological conditions of India and those of other parts of the world : the influence of solar activity also demands additional examination. The mechanism by which the meteorological features are controlled is very obscure and it seems necessary to accumulate empirical knowledge as to relationships for some time before making any attempt to explain the physical processes in action.

The extension of the area under examination has somewhat diminished the relative importance, from the standpoint of India, of the production of weather maps of the whole Indian Ocean, especially in view of the scantiness and inaccuracy of the data available. A report as to the possibility of devising a satisfactory method of preparing a monthly map has been submitted to the Government of India.

Study of the upper atmosphere.—Kites.—It is proposed to continue the experimental work which has been carried out at Belgaum in the course of the past year, and to learn more of the conditions of temperature, humidity and wind in the free air.

Balloons.—Some experience has now been gained as to the best material and methods for making light balloons, for the purpose of observation of velocities and directions of the upper air currents. Results already obtained have indicated that a considerable amount of information may be given by these balloon flights, and it is intended, therefore, to continue the work during the coming year. Arrangements are in hand also for using small balloons to carry up light meteorographs to considerable heights during times of little wind and to determine from the records so obtained the conditions of the free air over the plains at times when lack of wind precludes the use of kites. Information may thus be obtained by which the reduction of the barometer readings at high level station to sea level may be more accurately done than is at present possible.

Cloud Observations.—It is proposed to give a special training to three or four observers in different parts of India so that they may make cloud observations of a more accurate character than has hitherto been done; the results will be used in connection with the general enquiry regarding the higher air currents which is now in hand.

Daily weather work.—Storm and flood warning.—The preparation of files of weather charts showing pressure at 8 hours, changes of pressure since the previous day and the resulting rainfall should be continued, and the winter tour for 1906-07 of the flood and storm warning officer has been arranged with a view of ascertaining more closely the conditions and needs of the ports on the west coast in order that improvement may be made during the coming year in the methods of warning for stormy weather.

Solar Radiation.—Observations of the absolute value of solar radiation by means of Angstrom's electrical compensation pyrheliometers have been begun in Simla, and it is proposed to start systematic observations at an adjacent station in the plains also as soon as opportunity offers. The department has been presented by Dr. Sven Hedin with a pyrheliometer of the same type, but up to the present it has not been possible to send it to Simla from Srinagar, where it was left by Dr. Hedin.

Atmospheric Electricity.—For some little time measurements have been made thrice daily of the atmospheric potential gradients, and values of positive and negative ionisation and of the mobility of ions have been obtained periodically by means of Ebert's apparatus. This work should be continued, and it is hoped that the important task of ascertaining the sign and measuring the amount of electrical changes on rain and snow during various types of weather will be well in hand at the close of year 1907-08. Somewhat similar work has been in operation at Calcutta, and will be continued as far as circumstances permit.

Seismography.—The recording of earth movements by the Japanese seismograph which was lent to the department by Dr. Omori in 1905 should be continued, and when the more modern equipment, which has been on order for some time, has arrived from Japan all records of shock will be made in three directions, two horizontal and one vertical.

Among investigations which will be undertaken if circumstances permit are :—

- (1) The photographic measurement in Simla of heights of clouds.
- (2) The systematic examination of published seismograph records from various places, and their correlation with those produced in Simla.

Terrestrial Magnetism.—The routine work of the Bombay Observatory now includes—

- (a) the measurements of the magnetic elements at Alibag, both by visual observation and by means of self-recording instruments ;
- (b) the tabulation at Colaba of the data so obtained.

The magnetic records of the Colaba Observatory are being prepared for publication, and it is hoped that this work will be completed during the year. In addition to questions involving ordinary tabulation there are several which required special examination.

3. Survey of India (Research Work).

Gravimetric Survey.—Pendulum observations will be taken on the Mysore plateau and possibly on the Nilgiri hills. Observations of the plumbline will be taken round the Gulf of Cambay, and in the desert north-west of Deesa.

Magnetic Survey.—Colaba Observatory under the Meteorological Reporter and the four observatories under the Surveyor-General will continue to work : observations will be taken at 24 Repeat stations, and the preliminary survey will be continued.

Solar Photography.—Photographs of the sun will be taken daily at 10 A.M. and 4 P.M. at Dehra Dun, as has been done since 1879 in conjunction with Greenwich.

Himalayan Geography.—In conjunction with the Geological Survey, the Survey of India will publish a paper summarising the present position of Himalayan Geography and Geology.

4. Geological Survey.

- (1) Mapping of unsurveyed areas in the Shan States with examination of the lead-zinc mines in the Southern States.
- (2) Continued examination of the tin deposits in Mergui, Tavoy and Karenni with a general geological survey of the areas in which they occur.
- (3) Continued survey of the oil-bearing regions in the Irrawaddi valley and in the Arakan districts.
- (4) Survey of the volcano of Popa in the Myingyan district of Burma.
- (5) Continued examination of the copper-bearing belt in Singhbhum, with a Survey of the associated Dharwarian and Gneissose rocks.
- (6) Examination of manganese-mines in the Central Provinces, and newly opened deposits of manganese-ores in the Bellary district.
- (7) Extension of the geological map over unsurveyed areas in the Chanda and Raipur districts.
- (8) Further extension of the geological map over previously unsurveyed areas in Central India and neighbouring states of Rajputana.
- (9) Geological Survey of the Bugti hills with special reference to the fossil-vertebrate-bearing Tertiary rocks.
- (10) Chemical work on various brines from the Sambhar Lake, and on the samples of silt-bearing water collected from the Indus river.

(11) Palæontology of—

- (a) The Liassic rocks of Baluchistan.
- (b) The Lower Tertiary marine beds, specially of Baluchistan.
- (c) The Lamellibranchs of the Ranikot series of Sind.
- (d) The Cambrian Ordovician and Silurian of Spiti.
- (e) The Exotic blocks of the Bhot Mahals of Kumaon.

5. Botanical Survey.

I—COUNTRY UNDER THE SUPERINTENDENT OF THE ROYAL BOTANIC GARDEN, CALCUTTA.

- (a) **Bengal.**—An endeavour will be made to make a representative collection of the plants found in one or more of the Districts of Bengal to be utilized, it is hoped, ultimately in the preparation of District lists.
- (b) **Assam and Burma.**—The same policy will be pursued, as far as possible, within Assam and Burma.

II.—SURVEY OF BOMBAY.

Mr. Gammie, the officer in charge of the Survey of Western India, proposes, during the year 1907-08, to continue special investigations on the Ghats, some of the Deccan Districts, Guzerat and possibly Sind, and also to continue researches on the cottons and fodder grasses of the Bombay Presidency.

III.—SURVEY OF SOUTHERN INDIA.

The Government Botanist, Madras, states that there will be no room for tours in Systematic Botany in 1907-08 as he expects to apply for 18 months' leave from 1st April 1907.

IV.—SURVEY OF NORTHERN INDIA.

The Economic Botanist to the Government of the United Provinces states that he has no programme of operations of the Botanical Survey for 1907-08.

6. Agricultural Departments.

SECTION I.—PUSA AGRICULTURAL RESEARCH INSTITUTE.

(A) **Agricultural Chemistry.**—The Agricultural Chemist to the Government of India will be employed, among other things, on the investigation of the following problems :—

- (1) The availability of plant food (more especially phosphates) in soils, with reference to Dr. Dyer's method of determination will be studied in the Laboratory and Pot-culture House. The experiments will be extended to natural orders of plants other than the *Gramineæ*.
- (2) The composition of rain-water, dew and drainage water will be further investigated. The percolation through the soil will be determined in the special drain-gauges at Cawnpore and Pusa. In addition, a series of tests will be made to determine, throughout the year, the amount of moisture at varying depths in the soil.
- (3) An investigation will be made into the nature and quantity of gases contained in soils at various depths.
- (4) Amongst minor investigations may be mentioned (a) the testing of calcium cyanamide and calcium nitrate as manures; (b) the analysis of sugarcane juice; (c) the conditions under which glucosides are formed in *Andropogon sorghum*, *Manihot utilissima* and *Linum usitatissimum*.
- (5) A beginning will be made to determine, by ultimate analysis, the actual composition of the ordinary field and garden crops—the object being to obtain definite information regarding the manure requirements of each crop.
- (6) Analyses of the silt of selected rivers with regard to its composition and value for agricultural purposes will be continued.

(B) **Mycology.**—The programme of the Imperial Mycologist includes the following subjects :—

- (1) The investigation of soil fungi in their relation to plant life, with special reference to the symbiotic relation between certain fungi and the roots of a number of higher plants,

and also the part played by fungi in the decomposition of organic matter in the soil.

- (2) The investigation of the wilt-producing fungi of pigeon pea, pepper and other crops.
- (3) The study of sugarcane diseases.
- (4) The investigation of cereal and flax rusts, more particularly of wheat.
- (5) The study of some Indian smuts.
- (6) The study of a number of other fungus diseases of crops.
- (7) The continuance of the systematic survey of the Indian fungi.

(C) Entomology.—

- (1) The principal work of the Imperial Entomologist will be the trial of remedies for injurious crop pests on experimental farms, based upon the results of the investigations of previous years, which have been published in a book on Indian Insect Pests.
- (2) The treatment of insect pests infesting the crops grown at Pusa will be continued.
- (3) The work at the insectory will include (a) an investigation of the relation of climatic changes to the life histories of insects; (b) the study of methods of increasing the beneficial action of parasitic insects; (c) the testing of the action on insects of substances innocuous to cattle; and (d) the working out of the life histories of crop pests.
- (4) The insect survey of India will be continued, assistance in the identification of insects being obtained from workers in other countries.
- (5) The study of biting flies will be continued.
- (6) Assistance will be given in measures for the suppression of boll-worm in cotton in the Punjab, the scheme including the growth of trap crops, the introduction of beneficial parasites from other parts of India and other remedies.

(D) Economic Botany.—The Imperial Economic Botanist will devote his attention to the following subjects :—

- (1) The collection and investigation of fibre-yielding plants.
- (2) The improvement of Indian wheat, more particularly the rearing of new varieties by cross-breeding.

- (3) The study of varieties of Indian tobacco, barley and wheat.
- (4) Permanent experiments on the treatment of Indian fruits.
- (5) The study of varieties and cultivation of cassava.

(E) The Experimental Farm.—

- (1) The regular series of tests under uniform methods of treatment will be continued in order to prepare the way for comparative experiments.
- (2) A series of permanent field experiments will be started if the land is found to be uniform.
- (3) A systematic trial will be made of the efficiency of field agricultural implements, native and foreign, in use in India.
- (4) The cultivation of selected varieties of sugarcane will be continued.
- (5) The improvement of the herd of indigenous cattle for the supply of breeding bulls, and the testing of the Montgomery dairy herd for their acclimatization as milch cattle, will be continued.

(F) General.—In each special branch arrangements have been made for the training of probationers for provincial departments. It is anticipated that the College for post-graduate study will be ready to open by the end of 1907.

SECTION II.—SPECIAL INVESTIGATIONS.

1. The improvement of Indian cottons and wheats will be continued, in conjunction with provincial departments, in accordance with last year's programme. The scheme for the improvement of Indian tobacco will largely remain in abeyance until the appointment of a specialist for this purpose.

2. Other crops that are the subject of special investigation are (a) Tea, under the scientific department of the Indian Tea Association ; (b) Indigo, under the scientific department of the Behar Planters' Association ; and (c) Jute, under the fibre expert to the Government of Eastern Bengal and Assam. The programmes of work are similar to those of last year.

3. The trial of commercial fertilizers for Indian crops will be continued, more particularly the testing of mineral fertilizers for cotton sulphate of ammonia for sugarcane, and the introduction into more common use of saltpetre as a manure.

SECTION III.—PROVINCIAL DEPARTMENTS OF AGRICULTURE.

The programmes for next year generally follow those described in last year's programme placed before the Board of Scientific Advice, but the following important additions may be noticed :—

- (1) In the United Provinces, two new agricultural stations will be started, one at Aligarh for the improvement of cotton, and the second at Partabgarh for the study of rice and sugarcane. Experiments will be undertaken for the reclamation of alkali lands by the application of gypsum.
- (2) In the Punjab a new agricultural station will be started at Jullunder. The campaign against the cotton boll-worm will be continued. A start will be made with a systematic survey of the province with reference to the possibility of extending minor irrigation works, such as wells, water channels and embankments. An enquiry into alkali lands in the Chenab and Jhelum Colonies will be undertaken.
- (3) In Bombay a new botanical station has been started at Bassein. The survey of the cottons of the Presidency will be continued, and a survey of the wheats initiated. A comprehensive scheme of experiments in sugarcane has been started at the Manjri Station.
- (4) In Bengal, new agricultural stations will be opened at Bhagalpur and Bankipur. The investigation of Tassar silk will be undertaken at Chaibassa.
- (5) In Madras, the study of the cottons known as " northern " will be taken up at the Nandyal Agricultural Station. The botanist will extend his study of root parasites to the haustoria of *Cansjera*, *Ola*, *Ximenia* and *Opilia*. Special work will be undertaken to attempt to arrest the spread of the palmyra disease in the Godavari District.
- (6) Schemes have been completed for the establishment of Central Research Stations and Agricultural Colleges at Poona (Bombay), Lyallpur (Punjab), Cawnpore (United Provinces), Bhagalpur (Bengal), Coimbatore (Madras), Nagpur (Central Provinces) and Mandalay (Burma). A staff of three European specialists has been sanctioned for each.

7. Forest Department.

1. Further examination of tannin extracts, more particularly with extract obtained from barks of common Indian species of trees and treated by the decolorising process suggested by the Director, Imperial Institute, will be made.

2. The report of the expert engaged to enquire into the possibility of manufacturing wood and bamboo pulp in Burma on a commercial basis, has been received, and it is hoped that a profitable industry may shortly be started.

3. The collection for analysis of the latices of rubber-producing species will be continued.

4. The enquiry into the utilisation of the less valuable kinds of timber as railway sleepers will be continued and experiments will be made to ascertain whether any preserving process can be successfully used. A practical experiment will be made with sleepers obtained from *Dipterocarpus* sp. from Burma and the Andamans.

5. An enquiry regarding lac, and the best season for gathering it, is in progress and will be continued.

6. The collection of specimens of timber and other forest products will be continued for supply to the Reporter on Economic Products, and seeds of the more important indigenous species will be collected and sent, for experimental cultivation, to various British Colonies and Foreign countries.

7. Memoirs and Records of the Forest Department setting forth the results of investigations into various subjects affecting the progress of Indian Forestry will be published from time to time.

8. Various investigations will be made by the officers of the Imperial Forest Research Institute, Dehra Dun, including the following :—

An examination of the teak forests and plantations of Burma with special reference to the compilation of forest working-plans, and rates of growth of different species and enquiry into the possible utilisation of "In" (*Dipterocarpus tuberculatus*), and other so-called inferior species for sleepers, wood pavement and building.

Investigation in the United Provinces into the attacks of *Scolytidae* on the Deodar, Spruce, Blue pine and Silver fir and the

wood-boring *Cerambycidae* of the Oaks, the cone-mining pests of the Deodar and other conifers, the defoliating pests of the conifers and oaks, and the Autumn stages of the Silver fir and Spruce *Chermes*.

Further investigations into the flora of the Sonthal Parganas in order to complete a local flora of Chota Nagpur and a study of the morphological nature of the coppicing of sal (*Shorea robusta*).

The grasses of Savannah tracts in Bengal will be examined with special reference to their difference in burnt and unburnt areas, and a study will be made of the timber of different species of *tun* and *Grewia*, to ascertain which yield the most valuable wood.

8. Natural History Section, Indian Museum.

The Officiating Superintendent proposes to continue his work on the invertebrate fresh water fauna of India, and on the distribution of the lesser terrestrial fauna of the Himalayas. Arrangements have been made whereby one of the Assistants in the Museum shall be in the field collecting Zoological specimens during the greater part of the year. In the Entomological Laboratory the Entomological Assistant will pay special attention to the naming and arrangement of large collections of Hymenoptera and Hemiptera recently acquired, and to the sorting out of specimens in other groups which are to be sent to specialists in Europe and America for identification. It is hoped that a systematic study of the rats concerned or possibly concerned with plague may be commenced by the collection and mensuration of specimens from different parts of India.

9. Civil Veterinary Department.

1. An investigation into the etiology, course and prevalence of "Kumri" or Paralysis among horses. A disease which causes heavy loss in certain parts of India, especially in the Madras Presidency.

2. **Trypanosomiasis.**—This disease will be further studied in the horse, cattle and camel.

The points to which attention will be directed are :—

(a) The Natural History of the Trypanosome.

(b) The identity or otherwise of the Trypanosome infecting the horse, ox and camel.

- (c) The rôle played by biting flies in the spread of the disease, with a study of such flies.
- (d) The course of the disease in the camel.
- (e) More definite information regarding the nature and extent of the tracts in which the disease is prevalent.
- (f) Methods of prophylaxis and treatment.

3. **Piroplasmosis.**—Further observation will be made, as occasion arises, regarding the prevalence of this disease in cattle, horses and other animals, and its effects as a primary or secondary disease.

4. An enquiry into the comparative value of the serum and vaccine methods of prophylaxis against Anthrax, Charbon symptomatique and Hæmorrhagic Septicæmia, considered in conjunction with the peculiar conditions of the country and the facilities at the disposal of the Department.

5. **Hæmorrhagic Septicæmia.**—A further enquiry into the prevalence and course of this disease and the methods of establishing a correct diagnosis in the field.

6. Attention will be paid to any other disease to which during the year special attention is drawn and opportunity of study presented.

7. The preparation of sera, anti-toxins and vaccines will be continued.

The programme may appear an over-extensive one, but at present there are no facilities for the continuous and systematic study of any one disease, and the progress of investigation depends on the material which may be supplied to the Laboratory and on the opportunities which may arise of carrying out observations in the field.

APPENDIX.

APPENDIX.

ECONOMIC INVESTIGATIONS CONDUCTED FOR INDIA AT THE IMPERIAL INSTITUTE DURING THE YEAR ENDING 30th SEPTEMBER 1907.

BY

W. R. DUNSTAN, M.A., LL.D., F.R.S.,

Director of the Imperial Institute.

Numerous investigations relating to the composition and utilisation of Indian products have been conducted in the Scientific and Technical Department of the Imperial Institute during the past year at the request of various departments in India, conveyed, for the most part, through the Officiating Reporter on Economic Products to the Government of India.

The more important of these are briefly described below :—

Drugs.—*Aconites*.—The investigation of the various Indian aconite roots referred to in last year's report has been continued, but the work has been somewhat delayed by the pressure of other Indian investigations, particularly that on opium alkaloids, referred to below.

Solanaceous Plants.—Progress has been made with the isolation and characterisation of the alkaloids contained in the various species of *Hyoscyamus* and *Datura* which have been received from the Officiating Reporter on Economic Products.

Opium.—A new process for the manufacture of morphine and codeine from waste opium has been devised for use at the Opium Factory at Ghazipur. Preliminary commercial trials of this process were carried out at the Imperial Institute in the presence of the Factory Superintendent, and as these proved the feasibility of using the process in India, plant suitable for operations on the large scale has been designed and is at present being constructed in London, for despatch to India.

Strychnos species.—The seed of *Strychnos potatorum* is at present under examination in continuation of this enquiry.

Rubber.—Six samples of rubber have been received for examination during the year. Of these the best was a specimen of Para rubber (*Hevea brasiliensis*) from the Mergui Plantation, Burma, which proved to be of excellent quality. It compared favourably in composition and properties with Para rubber from plantations in Ceylon and the Federated Malay States, and was valued in London at 5s. 6d. per pound, at a time when "fine hard Para rubber" from South America was quoted at 5s. 2d. per pound.

Two samples of *Ficus elastica* rubber from the Kulsi Plantation were received. The first of these contained a rather high percentage of resin, but was valued at 4s. 3d. to 4s. 6d. per pound. The other sample consisted of "mat" rubber, and was weak, sticky and of inferior quality. It was valued at 2s. to 2s. 3d. per pound.

At the end of the year there remained under examination two samples of *Ficus* rubber and one of Ceara rubber.

Fibres.—*Cotton.*—A specimen of so-called "Buri Kapas" from the Singbhum District, Bengal, was found to be of American type and of satisfactory quality. Another sample from the same district, labelled "Lambua cotton," was of good colour and would be readily saleable. Three samples of "Caravonica" cotton grown from Australian seed were forwarded by the Director of Agriculture, Madras. These were examined and found to be similar to fine qualities of improved American Upland varieties.

Seven samples of cotton of various kinds, including native Indian, American, Peruvian and Caravonica, which were forwarded for examination by the Economic Botanist, Bombay, were, on the whole, of rather poor quality. Their chief defects were the presence of stains, apparently caused by insect pests, and of crushed seed due to imperfect ginning. It was recommended that means should be taken for combating the attacks of insect pests and that greater care should be exercised in ginning.

Five samples of American cotton, grown in the Myingyan District, Burma, were stained and partly immature, but were nevertheless of promising quality and could probably be improved by greater care in cultivation and the adoption of measures against insect pests.

Urena species.—A small sample of *Urena* fibre from Neltigandi was examined. It was of irregular length and not very well prepared but was regarded by commercial experts as suitable for spinning and

of probable utility for mixing with jute. It was recommended that greater care should be taken in retting, and that attention should be given to the length of the fibre.

Hibiscus species.—A sample of Hibiscus fibre, grown in the Ganesh-khind garden, Kirkee, was examined. It was badly prepared, but of promising quality. A recommendation was made that more care should be taken in retting the fibre.

Flax.—A sample of unretted flax straw grown from Riga seed at the Bankipore Agricultural Experiment Station was examined and compared with a standard specimen of Belgian flax. The straw was well grown, but rather coarser than the Belgian product and somewhat woody. It was considered that the seed had not been sown thickly enough, and suggestions were made as to the amount to be sown per acre and the age at which the straw should be gathered.

Musa Sheaths.—A consignment of the sheaths of *Musa textilis* was examined and submitted to technical experts. It was reported that the material would probably not realise more than £3 to £4 per ton for paper making, but that possibly the sheaths could be utilised for packing machinery and furniture.

Agave and Furcraea fibres.—Two samples of Agave fibres and one of Furcraea from the Anantapur District, and two specimens of Agave fibres from Assam are at present under investigation.

Dyes.—The investigation of four Indian dyestuffs has been completed by Mr. A. G. Perkin, F.R.S., of Leeds University, to whom they were referred.

The root bark of *Onosma echioides* was found to contain a red dye similar to the Alkannin, which occurs in alkanet root (*Alkanna tinctoria*). The latter is still used to some extent in commerce for dyeing oils, etc., but there is no prospect of finding a similar outlet for the *Onosma* root bark.

The flowers of *Hibiscus Sabdariffa* contain a yellow dyestuff, which gives poor shades, and this material cannot be recommended for use in dyeing.

The flowers of *Thespesia lampas* contain the well-known dye quercetin, but not in sufficient quantity to enable this material to compete with the natural yellow dyestuffs still employed to some extent in Europe.

The leaves and bark of *Baccaurea sapida* proved to possess no tinctorial property, and they are probably used in India only as an adjunct to other dyestuffs. This point is being enquired into by the Officiating Reporter on Economic Products.

Tanning Materials.—The enquiry into the commercial value of the samples of extracts made from the bark of *Rhizophora mucronata* at the Tanning Extract Factory at Rangoon was completed. This material proved to be fairly rich in tannin, but was too dark coloured to be suitable for use as a tanning agent without special treatment, as to which suggestions were made.

Oils and Oil-seeds.—The two oils received were derived from the seeds of *Amoora rohituka* and *Calophyllum tomentosum*. The first of these was compared with a sample of this oil examined at the Imperial Institute some years ago and proved to be quite different in properties, and information was asked for as to the authenticity of the sample. The oil was not of good quality and not likely to be of high commercial value.

The sample of oil of *Calophyllum tomentosum* was of poor quality and appeared to have been overheated in the course of preparation. It would probably be worth about £1 per ton less than cotton seed oil for soap-making.

Samples of the seeds and fats obtained from several species of *Bassia* were received and are at present under examination. The *Bassia* fats are important as it seems probable that they will meet the requirements of certain manufacturers.

Turpentine Oil.—This enquiry is still in progress. As the turpentine oil from *Pinus longifolia* appears to possess characteristic properties, a complete chemical examination of it is being made with a view to the identification of its constituents.

Resins.—A complete chemical examination of the resin of *Pinus longifolia* is being made as a part of the turpentine oil investigation.

A sample of black dammar resin was received and is at present under technical trial.

Foodstuffs.—Coffee.—Two samples of coffee, grown on the Arabidecool estate, Kadur District, Mysore, were submitted by the Agri-Horticultural Society for examination. The first sample was part of the 1904-5 crop from unmanured land. The second sample

was from the 1905-6 crop from the same land, which had in the meantime been manured with basic slag, saltpetre and poonac. Comparison of the two samples showed that as the result of manuring there were slight increases in the density, size and weight of the beans and in their content of alkaloid.

Prussic Acid in Plants.—Considerable progress has been made during the year with the investigation of cyanogenesis in plants, and a further study of the constitution of the glucoside phaseolunatin, and of the nature of the enzyme associated with it in flax, cassava and the beans of *Phaseolus lunatus* has been made. The results are given in a paper communicated by Professor Wyndham R. Dunstan and Drs. Thomas A. Henry and S. J. M. Auld to the Royal Society (*Proc. Roy. Soc.*, 1907, B, LXXIX, 315), copies of which have been sent to the Officiating Reporter on Economic Products.

Professor Dunstan has also published, in the "Proceedings of the Chemical Society" (1907, xxiii, 168), a preliminary note on the origin of the prussic acid of Para rubber seeds (*Hevea brasiliensis*), which indicates that these seeds contain phaseolunatin or some similar glucoside.

Some further work has also been done for His Majesty's Board of Agriculture on the subject of Rangoon beans. The early work by various investigators on white Rangoon or Burma beans all indicated that this variety yielded no prussic acid or mere traces, and that it could be safely recommended for use as a feeding stuff (compare "Bulletin of the Imperial Institute," 1906, iv, 329). Recently, however, white Rangoon beans have been sold in this country which yielded as much as 0.025 per cent. of prussic acid. This matter is still under investigation in consultation with the Board of Agriculture.

Minerals.—*Manganese Ores.*—The supplementary work on these ores, asked for by the Director of Geological Survey, involving the determination of the amounts of nickel and cobalt oxides, alkalis baryta, arsenious oxide and water, present in certain selected ores, has been completed and a supplementary report on the subject has been forwarded.

Laterites.—A report giving the results of the analyses of a series of laterites sent by the Director of the Geological Survey, has been forwarded to India and some further information as to the commercial

value and industrial possibilities of these laterites is now being obtained.

Concentrate supposed to contain pitchblende.—This concentrate from the Tsagpo river, was received from the Director of the Geological Survey. It was found to be slightly radio-active and to contain a trace of monazite and some thorium-uranium mineral. The sample was too small to permit of the identification of the latter.

Pottery Clays.—The preliminary examination of these has been completed, and a report is in preparation.

Miscellaneous.—The calorific value of cow-dung cakes is being determined at the request of the Director of Agriculture, Bombay, in order to ascertain the value of this material as fuel.

A considerable number of enquiries relating to the utilisation of Indian products has been received during the year both from firms in India and in this country, and in some cases these have been accompanied by samples of products for examination. The specimens so received include *inter alia* rubber, cotton, minerals and mother-of-pearl shells.

The following reports have been forwarded to India during the year:—

Report on Coffee from the Arabidecool Estate, Kadur District, Mysore.

Report on Laterites from the Central Provinces, India.

Report on Tanning Extracts from the barks of *Shorea robusta*, *Terminalia tomentosa* and *Rhizophora mucronata*.

Report on the Tanning value of extract from *Xylia dolabri-formis*.

Report on Sheathes of *Musa textilis*.

Report on the Colouring Matter of the roots of *Onosma echroides*.

Report on the Colouring Matter of the flowers of *Hibiscus Sabdarifa*.

Report on the Colouring Matter of the flowers of *Thespesia lampas*.

Report on the leaves and bark of *Baccaurea sapida*.

Report on a concentrate supposed to contain pitchblende.

Report on the Oil of *Calophyllum tomentosum* from India.

Report on the Oil of *Amoora rokituka* from India.

- Report on Para rubber (*Hevea brasiliensis*) from Mergui.
 Report on *Ficus elastica* rubber from the Kulsi plantation.
 Report on Cotton from Singbhum District, Bengal.
 Report on Lambua cotton from Singbhum District, Bengal.
 Report on Cotton from Burma.
 Report on a new process for the preparation of Morphine and Codeine from Indian opium.
 Report on Flax from Bengal.
 Report on Cottons from Madras.
 Report on Hibiscus fibre from Bombay.
 Report on the Floss of *Calotropis procera*.
 Report on *Orthanthera viminea* fibre.
 Report on Cottons from Bombay.
 Report on Urena fibre from India.

The following articles, dealing with subjects of importance to India, have been printed in the "Bulletin of the Imperial Institute" during the year :—

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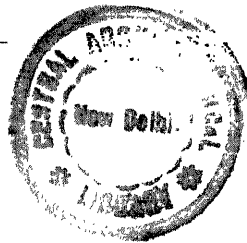
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